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ON TWIN HYBRIDS

HUGO DE VRIES

In the group Onagra of the evening primroses the hybrids between different species are, as a rule, constant and uniform through the succeeding generations. In this respect they comply with the common rule for the majority of the characters of specific hybrids. Only, on account of the scarcity of regressive marks in this group, the phenomenon of constancy is allowed to show itself pure and complete. An exception is afforded by *Oenothera brevistylis*, the character of which splits up according to the formulae of MENDEL.[1]

As an example of a constant hybrid race I quote the *O. muricata*× *biennis*. It has been found uniform through at least four generations. In the second, the one in which Mendelian marks are seen to split, I cultivated over 80 flowering plants and over 100 rosettes, but no differences could be detected. Last summer (1907) I cultivated, on neighboring beds, 35 plants of the first and 18 of the fourth generation. Both groups produced a number of flowering stems, but, apart from the ordinary fluctuating variability, the characters were exactly the same in all the specimens. They had the flowers almost like those of *O. biennis*, but dense and richly flowered spikes like the *O. muricata*.

The types of the species used for this experiment were the forms which occur everywhere on waste places throughout Europe, having been introduced, the first from Virginia and the second from Canada, about three centuries and one century ago respectively. They are probably the types on which LINNAEUS based his descriptions of the species. In the United States, however, these Linnean species con-

[1] Die Mutationstheorie 2:429.

sist of quite a number of subspecies, of which I collected over a dozen in Kansas, Missouri, Illinois, and elsewhere, during the summer of 1904. On sowing them in my experiment garden, I observed them to be fairly distinct, each constituting a sharply defined type. The form which is the most common throughout the United States is not the same as the one introduced into Europe, neither for *O. biennis* nor for *O. muricata*, as has also been pointed out by MACDOUGAL for *O. biennis*.

All these numerous elementary species agree with one another in a most interesting character. Their anthers touch the stigma, open themselves in the bud, and produce fertilization before the flower opens. The process is almost entirely finished before the insects are admitted. Crosses seem to be very rare in nature, although they do occur, since I collected the hybrid of *O. muricata* and *O. biennis* in the dunes near Amsterdam, and even more than once. A simple means of pure self-fertilization may be derived from this pollination within the bud. I cut the buds of our *O. biennis* one or two hours before opening, cutting through the middle of the tube, and the pods developed as strongly and produced as many good seeds as those whose flowers were allowed to be visited by bees. The flowers of *O. Lamarckiana*, *O. Hookeri*, and other large-flowered species, on the contrary, are not fertilized in the buds, but are in need of the help of insects (moths, bees, and bumble-bees).

The specific hybrids of this group of Onagra differ in a very conspicuous way from ordinary hybrids in so far as the reciprocal forms often are not identical, but differ widely from one another.[2] Although I have observed this fact in numerous cases, it is not a general rule. The hybrid *O. Lamarckiana*×*gigas* is identical with *O. gigas*× *Lamarckiana*. In the same way the species of the subgenus Euoenothera crossed with those of Onagra yield uniform hybrids. I crossed the *O. Sellowii* with *O. biennis*, *O. muricata*, and *O. Lamarckiana* and observed their reciprocal hybrids to be identical.

Within the group of the Onagras, however, the reciprocal hybrids are in most cases different, and with a few exceptions are more similar to their father than to their mother. They are, as it is called, patroclinous. So it is, for instance, with the reciprocal hybrids of *O. muri-*

[2] Die Mutationstheorie 2:471.

cata and *O. biennis* in their subspecies from our European dunes. The *O. muricata*×*biennis* looks like *O. biennis* and might be mistaken for it, since it is broad-leaved and large-flowered. The *O. biennis*× *muricata*, on the other hand, is narrow-leaved and small-flowered like its male parent. During the summer of 1907 I cultivated the first and second generations of the latter type and found them uniform, but in almost all respects different from the *O. muricata*×*biennis*. Especially the flowers are of a deep yellow and strongly scented, while those of *O. muricata*×*biennis* are pale and faintly scented.

This difference between the reciprocal hybrids is also clearly manifest in the crosses of *O. Lamarckiana* with the types of our dunes. The *O. Lamarckiana*×*biennis* has been described in my *Mutationstheorie* (**2**:31) for two generations, the third having only been cultivated in 1907. The *O. Lamarckiana*×*muricata* has been described and figured in the same volume (see page 29), but I have not as yet succeeded in getting a second generation, partly on account of the weakness of the type and partly on account of the general phenomenon of strongly diminished fertility in all these primrose hybrids.

The reciprocals of the two hybrids just mentioned afford the curious and rare phenomenon which I call that of the *twin hybrids*. In crossing one spike of *O. biennis* with the pollen of one plant of *O. Lamarckiana*, one does not get one but two hybrid types. The same holds good for *O. muricata*. These forms are intermediates between the parents and almost alike when seen from a distance, but sharply distinguished when closely examined. These differences are the same whether *O. biennis* or *O. muricata* is the mother plant, the hybrids showing their divergent origin only in apparently subordinate marks. One of the twins has broad and flat leaves of a bright green; I call it *O. laeta*. The other has narrow, more or less furrow-shaped leaves of a grayish green, which are more hairy, and is therefore designated *O. velutina*. These same names may be used to distinguish the twins in all the hybrid combinations in which they may occur.

The twin hybrids, *O. laeta* and *O. velutina*, occur in numerous hybrid combinations where *O. Lamarckiana* or one of its mutants is the pollen parent; as for instance with *O. brevistylis*, *O. rubrinervis*, and *O. nanella*. In these cases they drop, at least in the first

generation, the special mark of the mutant-father, and so are the same in all the cases named. The mother plant may be *O. biennis*, *O. biennis cruciata* (a form of *O. biennis* with linear petals which occurs in the dunes of Holland), *O. muricata*, or some other species of Onagra, although not all of them are capable of producing twins.

In the cases named the twins are widely different from their reciprocal hybrids, but closely related between themselves. Their characters often show transgressive fluctuability, and as a result of this they are more easily distinguished at some periods of their life than at others. The better the culture and the stouter the plants, the larger and more striking are the differences. Especially specimens which contrive to make a large rosette of root leaves before they send up their stem, and therefore begin flowering only late in the fall, are liable to display their differential marks in a most striking manner.

The twins are usually produced from the same cross in about equal numbers. On account of their highly diminished fertility it is difficult to get large cultures of their progeny, for even when the pods are large and contain an apparently full supply of seed, the germinating percentage is often very small. The following figures, however, will suffice to state the fact.

TABLE I

O. LAETA AND O. VELUTINA IN FIRST GENERATION

Mother	Father	Number of progeny	Percentage of laeta	Percentage of velutina
O. biennis	×O. brevistylis	85	47	53
O. biennis	×O. rubrinervis	50	42	58
O. b. cruciata	×O. brevistylis	91	48	52
O. muricata	×O. Lamarckiana	58	61	39
O. muricata	×O. brevistylis	120	59	41
O. muricata	×O. nanella	59	58	42
	Average		52	48

In this experiment the parents have been those described above, and the crosses have been made by myself in the summer of 1905. The countings have been made during the flowering-season of 1907, only a small part of each of the cultures having remained rosettes; but the distinguishing marks in these were as evident in the fall, as those of the flowering plants. Some crosses, tried in previous years, had given the same results and prepared the method for an exact counting.

In the young plants, before the sending-up of the stems, it is of course easy to count far larger numbers of plants, but the influence of transgressive fluctuability is somewhat greater. I counted for *O. biennis*×*brevistylis* 287, for *O. biennis*×*Lamarckiana* 347, and for *O. biennis cruciata*×*brevistylis* 208 seedlings, and found 55 per cent., 60 per cent., and 64 per cent., or on an average 60 per cent. specimens of *O. velutina*, the remaining 40 per cent. being *O. laeta*. The figures, although from the cause given not as exact as those given above, evidently confirm the result.

Tried in the second generation, from artificially and purely self-pollinated seed, each of the twins yields a uniform progeny, with exactly the same characters as its parent. Therefore they may be considered as constant hybrid races. I made the majority of the crosses of the following table in 1903; had the first generation, which often consisted of only a few specimens on account of the diminished fertility, in 1905; and counted the forms in the second generation during the flowering-period of 1907. Most of the plants were counted in full flower, some of them, however, in the condition of rosettes of root leaves. Only for *O. muricata*×*brevistylis* the cross was made in 1905 and the second generation grown in 1906.

TABLE II

CONSTANCY OF O. LAETA AND O. VELUTINA IN SECOND GENERATION

Cross	First generation	Second generation laeta	Second generation velutina
O. biennis×Lamarckiana	laeta	13	0
	velutina	0	9
O. biennis cruciata×Lamarckiana	laeta	19	0
	velutina	0	3
O. muricata×Lamarckiana	laeta	4	0
	velutina	0	53
O. biennis×rubrinervis	laeta	30	0
	velutina	0	6
O. biennis cruciata×rubrinervis	laeta	22	0
	velutina	0	3
O. muricata×brevistylis	laeta	34	0
	velutina	0	57
Total		122	131

I also tried this result by counting seedling plants as soon as they clearly showed their differentiating marks. From *O. laeta* seed I got

only *laeta;* from *O. velutina* seed only *velutina.* The observed cases for *O. laeta* were: *O. biennis*×*rubrinervis* (150), *O. biennis cruciata*× *Lamarckiana* (18), the same×*O. rubrinervis* (143); and for *O. velutina, O. muricata*×*Lamarckiana* (126), the same×*O. rubrinervis* (195), and the same×*O. brevistylis* (190). The figures in parentheses show the numbers of seedlings observed; together they give 311 seedlings of *O. laeta* and 511 of *O. velutina.*

It should be stated here that in the cross between *O. muricata* and *O. brevistylis* the character of the last-named species followed the Mendelian law in the case of both of the twins. The 34 *O. laeta* contained 30 per cent., and the 57 *O. velutina* 21 per cent., together also 26 per cent., of short-styled individuals, which bore in their leaves and flower-buds and in the flattened lobes of their stigma all the characteristics of their male grandparent. The *O. brevistylis* character is thereby shown to be independent of the hereditary units which cause the production of the twins.

The third and fourth generations have been cultivated in only one case, as yet, which was a cross made between *O. muricata* and the pollen of *O. Lamarckiana* in 1901. The *O. laeta* in this case was entirely sterile, and so only the *O. velutina* could be studied. It gave a constant progeny of small extent, the fertility in artificial self-pollination remaining in a diminished condition.

TABLE III

CONSTANCY OF O. VELUTINA DURING FOUR GENERATIONS

Cross of O. muricata×*O. Lamarckiana*

Generation	O. laeta	O. velutina	O. laeta from O. velutina
Cross, 1901	—	—	—
1st generation, 1902	35 (sterile)	35	—
2nd generation, 1903–4	—	27	0
3rd generation, 1905	—	53	0
4th generation, 1907	—	60	0

All in all 175 plants were observed, all bearing the same characters.

The phenomenon of twin hybrids seems to be very rare in plants. There can be do doubt that its occurrence in *Oenothera Lamarckiana* is intimately connected with at least part of the special manner in which this species displays its mutability. The production of some of the mutants seems to be quite dependent upon it, though that of

others is independent. But I must reserve an account of my experiments on this point for another occasion.

SUMMARY

1. Hybrids between members of the group Onagra or the *O. biennis* group of the evening primroses are, as a rule, constant in succeeding generations. An exception is *O. brevistylis*, the character of which follows MENDEL'S law.

2. The reciprocal hybrids of this group are, as a rule, unlike one another, and mostly patroclinous.

3. In many cases, where *O. Lamarckiana* or one of its derivatives is the father, two forms of hybrids are produced instead of one. These forms may be called twin hybrids.

4. One of the twins is broad and smooth-leaved and is called *O. laeta;* the other is more hairy and has furrow-shaped leaves, and is designated as *O. velutina.*

5. *O. laeta* and *O. velutina* are produced by the combinations *O. biennis*×*Lamarckiana* and *O. muricata*×*Lamarckiana,* and by those of some of their derivatives.

6. They are produced in about equal numbers.

7. They remain constant in the second generation. In the only ascertained case they also showed themselves so in the following generations.

AMSTERDAM

A CONTRIBUTION TOWARD A KNOWLEDGE OF THE GENUS WASHINGTONIA

S. B. PARISH

(WITH TWELVE FIGURES)

"We followed the sandy bed of the Carriso nearly all day at a snail's pace, and at length reached the 'little pools,' where the grass was luxuriant, but very salt. This valley is at no point more than half a mile wide, and on each side are mountains of gray granite and pure quartz. A few miles from the spring called 'Ojo Grande,' at the head of the creek, several scattered objects were seen, projected against the cliffs, hailed by the Florida campaigners, several of whom were along, as old friends. They were cabbage trees, and marked the *locale* of a spring, and a small patch of grass."

In these words we have the record of the discovery of the Washington palm. The date was November 28, 1846, and the discoverers were the party of the military reconnoissance under Major W. W. EMORY, now nearing the end of their long journey, through unexplored mountains and arid deserts, from the Missouri River to San Diego.

Seven years later a company of surveyors under W. P. BLAKE, engaged in exploring a route for the projected Pacific Railroad, entered the Colorado Desert through the San Gorgonio Pass, on their way to Fort Yuma, the route now followed by the Southern Pacific Railway. On November 15, 1853, they reached a little nook, nestled under the shadow of rugged San Jacinto Mountain, which afterward came to be known as Agua Caliente, and more recently as Palm Springs. "A growth of rushes," says the itinerary, "forms a narrow margin of green vegetation around the spring and its outlet. Willows and mesquite bushes grow there also, and I found a young palm tree, spreading its broad, fan-like leaves among them. The surrounding desert and the palm tree gave the scene an oriental aspect." Hidden in nearby canons were groves of some of the noblest palms of the whole desert region, but the travelers passed on unaware of their presence.

Dr. C. C. PARRY has recorded ('81) that he also became acquainted with the desert palms in 1849–1850, while botanist of the Mexican Boundary Survey. But in the introduction to the *Botany* of the boundary he made no mention of these notable trees, while enumerating so many of the remarkable plants of the Colorado Desert. Neither do they find a place in the body of the volume; nor are they mentioned by the botanists who reported upon the collections of the Pacific Railroad Surveys.

Not until 1861 did they receive botanical recognition, and was an attempt made to assign them a systematic position. In that year Dr. J. G. COOPER published (Smithsonian Report for 1860) the names of certain trees "omitted, by an oversight, from a list of those on the Mexican boundary" which had appeared in a preceding report. Last on the list appears "Brahea? dulcis? Mart." COOPER had leaves, collected, he states, by Dr. SUTTON HAYES, at Palm Springs[1] and he notes their thready segments and prickly petioles, and states that the fruit is edible.

The matter rested here for eleven years more, when the attention of European botanists was attracted to some young palms grown at Ghent, by the enterprising house of LINDEN, from seed reported to have come from the arid interior of our Pacific coast. At first they were thought to belong to Brahea or to Prichardia, but in 1879 Dr. H. WENDLAND, the most eminent palmographer of the time, became convinced of their generic distinctness, and gave the name Washingtonia, "in honor of the great American," to the palms which, he says, had been known in gardens as *Brahea* or *Prichardia filifera*.

THE GENERIC NAME

It appears, however, that there had been some previous suggestions as to the bestowal of the name of Washington upon certain

[1] Probably not the Palm Springs of BLAKE's Report. Dr. HAYES accompanied as assistant surgeon the government expedition which in 1858–59 surveyed an emigrant route from El Paso to Fort Yuma. Later he made some botanical collections near San Diego, and probably traveled to that town from Fort Yuma by the same road taken by EMORY'S party, the customary route at that time. This "Palm Springs" may well have been that of EMORY. There is a sketch of Dr. HAYES's life in Seeman's Jour. Bot. 1:254. 1863, and substantially the same account in Biologia Cent.-Am. Botany 4:153.

other plants. A Dr. WINSLOW had proposed that the Californian Sequoias might fitly bear that honored name. For this reason SUDWORTH, in 1897, proposed ('97) to substitute for WENDLAND'S name the cacophonous chloronym *Neowashingtonia*. In this he has been followed by some American nomenclaturists, but not by European palmographers.

In the same year BRITTON and BROWN[1a] transferred the umbelliferous plants commonly known as Osmorrhiza to *Washingtonia* Raf., a disposition subsequently accepted, with confessed reluctance, by COULTER and ROSE.[2]

It would seem evident that one of the leading principles which should govern, if a stable nomenclature is to be attained, is that the code should not be interpreted in the interest of novelty. Changes of name should be made only on clearest evidence of their necessity, and in all cases of reasonable doubt the name in possession should be left undisturbed. Tried by this standard it does not appear that either of these proposed changes is justifiable. WINSLOW'S alleged publication is valid neither in its character nor in its vehicle. It occurs in the course of a rambling popular account of a visit to the Sierra Nevada, published in the *California Farmer* of August 24, 1854, a farmer's weekly of the ordinary type. Possibly the original defect might be considered to have been cured by the quotation of some paragraphs of WINSLOW'S letter in an article on "The big tree," by HOOKER,[3] and by CARRIÈRE'S citation in the synonymy under *Wellingtonia gigantea*.[4] In any event, Washingtonia as a name for the Sequoias lapsed at once into hopeless synonymy, leaving it, under the International Rules of Botanical Nomenclature, open for subsequent use.

The facts in the other case are these. In 1818, in a review of PURSH'S *Flora*, RAFINESQUE remarks that, in his opinion, *Chaerophyllum Claytoni* Pers. had been incorrectly referred; and he continues: "Several names have been proposed for it, Washingtonia, Osmorrhiza, Gonantherus, but these are not yet published; the second

[1a] BRITTON and BROWN, Ill. Fl. 2:530. 1897.

[2] COULTER and ROSE, Monog. Umbell. Contrib. U. S. Nat. Herb. 7:61. 1900.

[3] HOOKER, Jour. Bot. and Kew Garden Misc. 7:26 *et seq.* 1855.

[4] CARRIÈRE, Traité des Conifères, Ed. 2, 217. 1867.

FIG. 1.—*W. filifera* Wendl. (the right-hand tree) in the Botanical Garden, Palermo, Italy.

is perhaps the best,"[5] and in the following year he did *publish* this second name.[6] In order that we may be enabled to make a confusing change in two familiar names, therefore, we must hold that RAFINESQUE published a name when he expressly disclaimed so doing, and did not publish it when he formally undertook the task.

NAME OF THE TYPE SPECIES

Here it is convenient to consider another nomenclatural question. WENDLAND'S original species was published as *W. filifera;* but in his *Revisio,* KUNTZE ('**91**) proposed to change it to *W. filamentosa,* on the ground of priority, citing in support "*Brahea filamentosa* Wendl. in Cat. Haage & Schmidt (1875), *Prichardia filamentosa* Wendl. ex Fenzi in Bull. Soc. Tosc. (April, 1876)." To seek in a tradesman's catalogue for a pretext for displacing an established name, requires a lust for change almost amounting to a mania. But if an appeal to trade-lists is to be made, priority is against the change, for HAAGE and SCHMIDT offered *Brahea filamentosa* in their autumn catalogue of 1875, but in the spring of the same year LINDEN in his list had put the same plant on the market as *Prichardia filifera* (FENZI '**76**). *Prichardia filamentosa* of FENZI'S paper is a *nomen nudum,* being without a word of scientific description, or any reference to a published species. As the proper specific name, *filamentosa* has absolutely no standing.

THE SOURCE OF WASHINGTONIA FILIFERA

When we pass from the consideration of names, we find ourselves confronted by questions of greater difficulty. What precisely was the palm variously known to gardeners and seed-dealers as *Brahea filifera* or *Prichardia filamentosa,* and to which WENDLAND gave the name *Washingtonia filifera,* and whence came it? WENDLAND had before him a few[7] young trees which had been grown in the palm-

[5] Am. Month. Mag. **2**:176. 1818. This publication is invalid under the Laws of Nomenclature formulated by the Botanical Club of the A. A. A. S. See Canon 12 of the latest revision of that code, in Bull. Torr. Bot. Club **34**:171. 1907.

[6] Jour. Phys. **89**:257. 1819.

[7] There could have been but few of these trees, for, in a letter to the writer, M. LUCIEN LINDEN, the present head of the house, writes: "Vers 1872 mon père a reçu d'un dizaine des graines de ce palmier qu'il avait rapporté d'un voyage en Californie." In his original description WENDLAND states that it was introduced by LINDEN in 1869, but this is evidently an error.

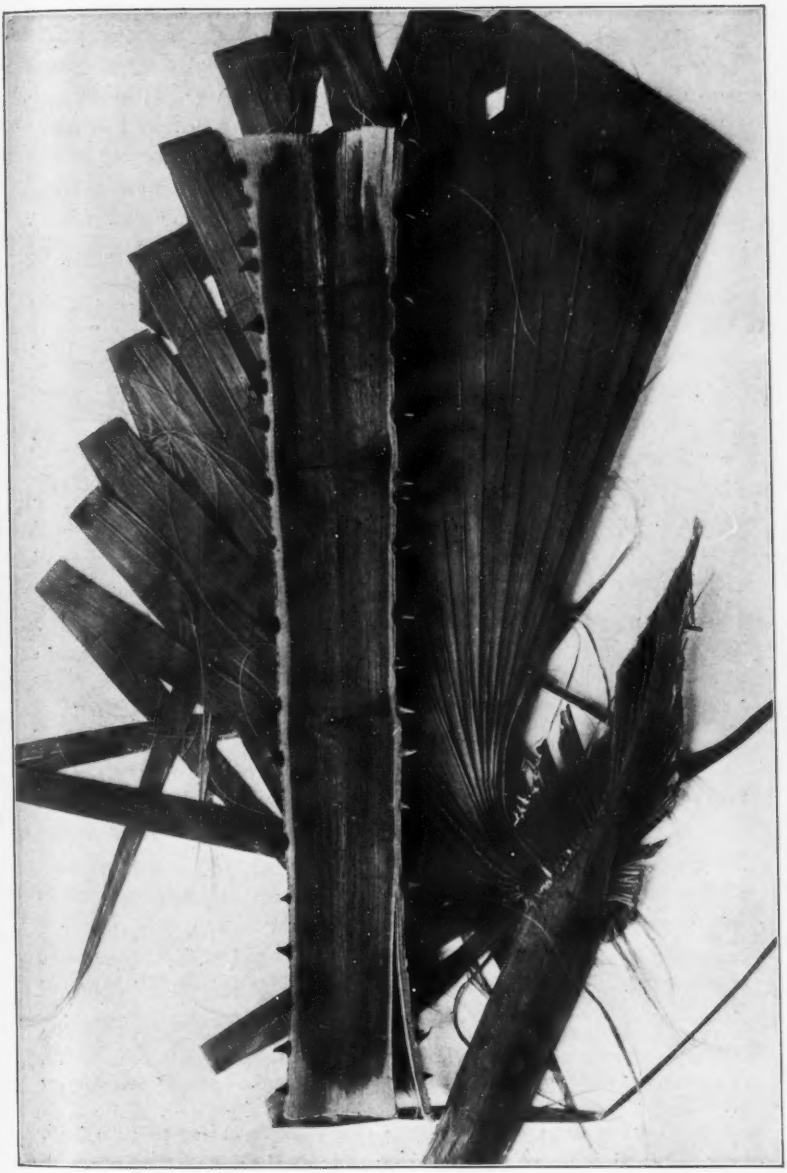

FIG. 2.—A leaf from the tree shown in *fig. 1*.

houses of LINDEN in Ghent. It seems certain that the seeds were brought to Europe by ROEZL.[8] They purported to have been collected in Arizona, near the Colorado River, and FENZI ('76)[9] even gives latitude and longitude, which would locate the parent trees in the neighborhood of Prescott, Arizona, a region rather of pines than of palms. Definite as are these statements, it is impossible that ROEZL ever could have seen a Washingtonia growing spontaneously or have collected its seed. The seeds which he carried to Europe he must have received from another, probably in San Francisco, and with them an inaccurate or misunderstood account of their source.

ROEZL appears to have made but a single visit to America. He left Europe in August 1872, landing at New York, and proceeding by way of St. Louis to Denver, where he made his headquarters. On September 6 he wrote from that place that he had sent home six boxes of *Yucca angustifolia*, some cactuses, and bulbs of Calochortus. He then made a trip, of a fortnight's duration, into northern New Mexico, where he saw *Abies concolor*, *Yucca baccata*, and *Ipomoea leptophylla*. On October 3 he wrote from San Francisco, telling of his route, by the Union and Central Pacific Railways, through Utah and Nevada. He remained in San Francisco until about November 1, when he sailed for Panama.[10]

The early reports of the location of the parent trees proving unreliable, we are left without any authentic information as to the source of LINDEN'S seeds. They may have come from native trees in the region now known to be occupied by these palms, or from some of the older cultivated trees in southern California. There is reason to believe that some of the earliest subsequent importations of seed were collected by the late GEORGE W. DUNN in Cantillas Cañon, on the desert borders of northern Lower California.

[8] "Es ist nämlich von RÖZL, in Nord-Mexico, bei Arizona, am Rio Colorado, eine Corephine gesammelt worden, welche unter dem Namen *Prichardia filamentosa* jetzt in den Handelgärten gezogen wird" (DRUDE '76).

[9] "La scopeta di questa Palma se debba all' intrepide B. ROEZL, che l'aviabbe retrovata nell' Arizona (Stati Uniti), dove cresca spontanea sulle rive del Colorado, a circa 115° de longitudine ouest del meridiano de Parigi, e circa de 35° latitudine nord."

[10] Notices of ROEZL may be found in Gartenflora 1874:49; 1889:330; Jour. Bot. 1874:384; Gard. Chron. 2:521. 1889. He died at Prague, October 14, 1889, at the age of 61 years.

WASHINGTONIA ROBUSTA

If we turn from this fruitless attempt to trace the indigenous origin of WENDLAND'S *W. filifera* to his description of that plant, we find it unsatisfactorily vague, as is also the later characterization of his second species, *W. robusta;* while among writers and cultivators there exists great confusion and misapprehension as to the identity of the two species.

This second species WENDLAND ('83) founded on young plants grown by VAN HOUTTE at Ghent, and its ascribed indigenous source

FIG. 3.—*W. filifera* var. *robusta* (Wendl.) Parish; very old trees at the western margin of the ancient lake bed, Colorado Desert.

is manifestly apocryphal, since it was asserted to be "the borders of the Sacramento River." VAN HOUTTE received the seeds under the name of the species already known, and under that name their product was at first sold, until WENDLAND recognized them as distinct, and published the name *W. robusta* (ANDRÉ '95).

It is significant that about this time collectors began to secure palm seed at Palm Springs, in the Colorado Desert. I am convinced that this place was the true source of WENDLAND'S second type. Certain it is that the trees growing there are identical with those now recognized in Europe as representing that species. It was on material from this station that WATSON ('80) based his characterization of

the genus and of *W. filifera*, the first formal and satisfactory description of either genus or species.

CONFUSION RESPECTING THE SPECIES

From what has now been stated it will be understood that confusion might readily arise as to the identity of these two species. Each was insufficiently described from young plants growing under glass; and the indigenous source of each was either misapprehended or misrepresented. Added to this is the undoubted fact that soon after the publication of the second species, certain dishonest dealers were accustomed to fill orders for either from the same drawer, the only difference being in the price. Moreover, in recent years, through honest misunderstanding, the seeds supplied to the market as "true *W. robusta*" belong in reality to an undescribed species. Naturally the product of these falsely named seeds adds to the confusion. It happens, therefore, that neither of the palms known in California as *W. filifera* and *W. robusta* bears its true name.

A clue in these difficulties would be found could we ascertain exactly what was WENDLAND'S *W. filifera*, but this seems impossible. The only practical course is to accept as representing this species certain mature trees growing in the Riviera, which are recognized by European authorities as authentic specimens of WENDLAND'S two palms. They are distinguished by a character which does not appear in either of the original descriptions, and one too marked, it would seem, to have been overlooked. Yet in the native groves of the desert, where it is to be seen, it has been overlooked by the many accomplished botanists who have visited them. While not entirely satisfactory, this seems the best disposition attainable, and I have adopted it in the following key, which represents my present understanding of the genus.

KEY TO WASHINGTONIA

Petiole acuminately prolonged in the blade.
  Blade abundantly filiferous.
    Margins of the petiole unarmed near the blade.....1. *W. filifera.*
    Margins of the petiole armed throughout.....1*a*. *W. filifera robusta.*
    Margins armed only near the base.....1*b*. *W. filifera microsperma.*
  Blade destitute of filaments or nearly so.....2. *W. gracilis.*
Petiole obtuse at junction with the blade.....3. *W. sonorae.*

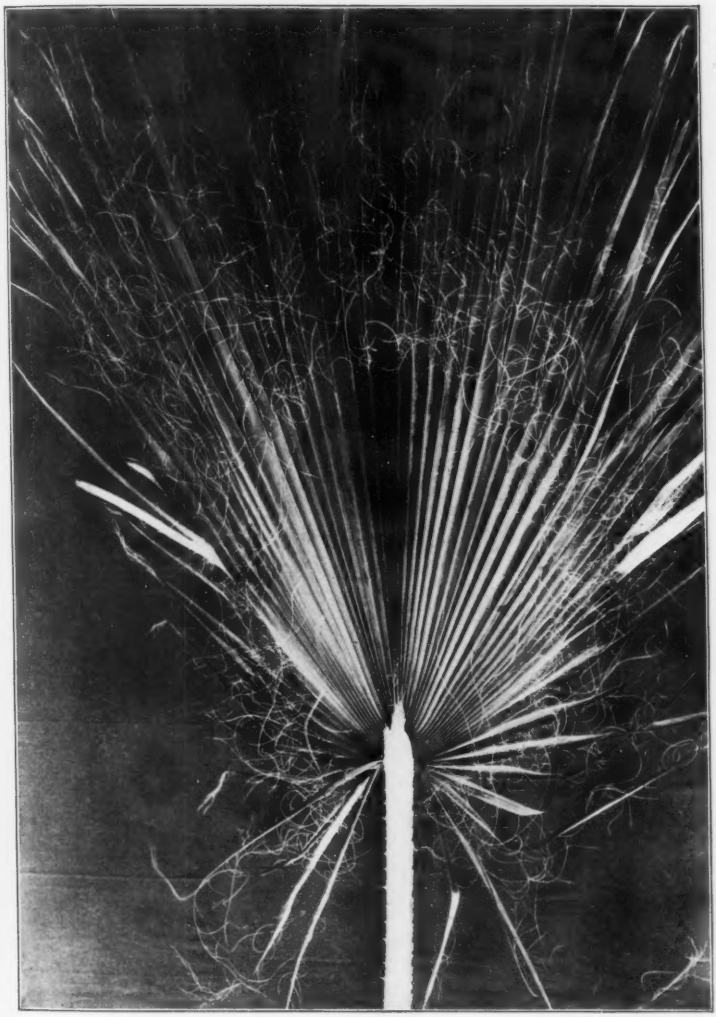

FIG. 4.—Leaf of *W. filifera robusta*, from a cultivated tree at San Bernardino, California.

1. WASHINGTONIA FILIFERA Wendland, Bot. Zeit. **37**:68. 1879.—*Figs. 1, 2.*

Margins of the petioles armed to the middle, or somewhat higher, naked above; otherwise as in the following variety, so far as known.

There seems to be no reason for selecting this form as representing WENDLAND'S species except that European palmographers so

FIG. 5.—Panicle, in full flower, of *W. filifera robusta*, from a cultivated tree at San Bernardino.

regard trees having this character which are growing in the Riviera. There are some trees thus armed growing in the native groves at Palm Springs, and they appear not to differ otherwise from the fully armed ones. In the same groves there are also young palms, probably five or six years old, having petioles without the usual corneous margin, and armed only with weak prickles, or nearly destitute even of these. No mature trees of this kind were seen. A similar difference is

FIG. 6.—*W. filifera* var. *microsperma* Beccari; in the gardens of Count Parravicino, Campo Romano, near Viareggio, Tuscany. This tree was planted in 1878, when 4–5 years old, and flowered for the first time in 1902.

reported in the armature of the petioles of *Erythea edulis*, some trees having naked petioles, while others show rudimentary spines.

1*a*. WASHINGTONIA FILIFERA Wendl. var. **robusta,** n. comb.—*W. robusta* Wendland, Garten Zeit. **2**:198. 1883; *W. filifera* S. Watson, Bot. Cal. **2**:211, 485. 1880, and of American gardens; *W. filamentosa* Kuntze, Rev. Gen. Pl. **2**:737. 1891; Sargent, Sylva **10**:47. *pls. 5–9*. 1891; *Neowashingtonia filamentosa* Sudworth, U. S. Dept. Agr., Div. For., Bull. **14**:105. 1891.—*Figs. 3–5*.

Trunk stout, enlarged at the base, 20–27^{m} tall: petioles stout and until old erect, 1–1.5^{m} long, 1–1.25^{dm} wide at the dark-brown base, and one-half as wide at the blade; the upper surface concave, its thin, light-brown margins corneous and armed for their entire length with stout hooked spines, acuminately prolonged into the blade; ligule papyraceous, acuminate, lacerate, 2–5^{cm} long; blades 1–1.5^{m} in diameter, the 60–70 folds deciduously tomentulose on the lower edges, cleft two-thirds to the base, the margin of the divisions abundantly filiferous: panicle declined, exceeding the leaves, the primary branches 4–5, each bearing 2–5 separated thryses, which are exceeded by their ligulate, chartaceous, spathoid bracts; infloresence dense, but becoming diffuse in fruit: seed excavated on the raphal face.

Borders of the Colorado Desert of southern California, at low altitudes, seldom exceeding 350^{m}.

The flowers and fruit have been well described by WATSON. The flowers are copiously nectariferous, and exhale a heavy odor, disagreeable when near by, but when diffused somewhat suggestive of the perfume of orange blossoms.

1*b*. WASHINGTONIA FILIFERA Wendl. var. **microsperma** Beccari in litt., n. var.—*Figs. 6, 7*.

"A smaller tree, margins of the petioles armed only at the base." Differing in these respects only from the preceding.

Growing in the Riviera, but as yet not noticed in the natural groves.

2. **Washingtonia gracilis,** n. sp.—*W. robusta* of California gardens, not of WENDLAND.—*Figs. 8–10*.

Trunk slender, at least 20^{m} tall: petioles rather convex on the upper surface, 7–10^{dm} long, about 1^{dm} wide at the brown base and one-half as wide at the blade, the corneous margins armed with short hooked yellow spines for the entire length, acuminately prolonged in the blade; ligule papyraceous, narrow, the margin entire; blade

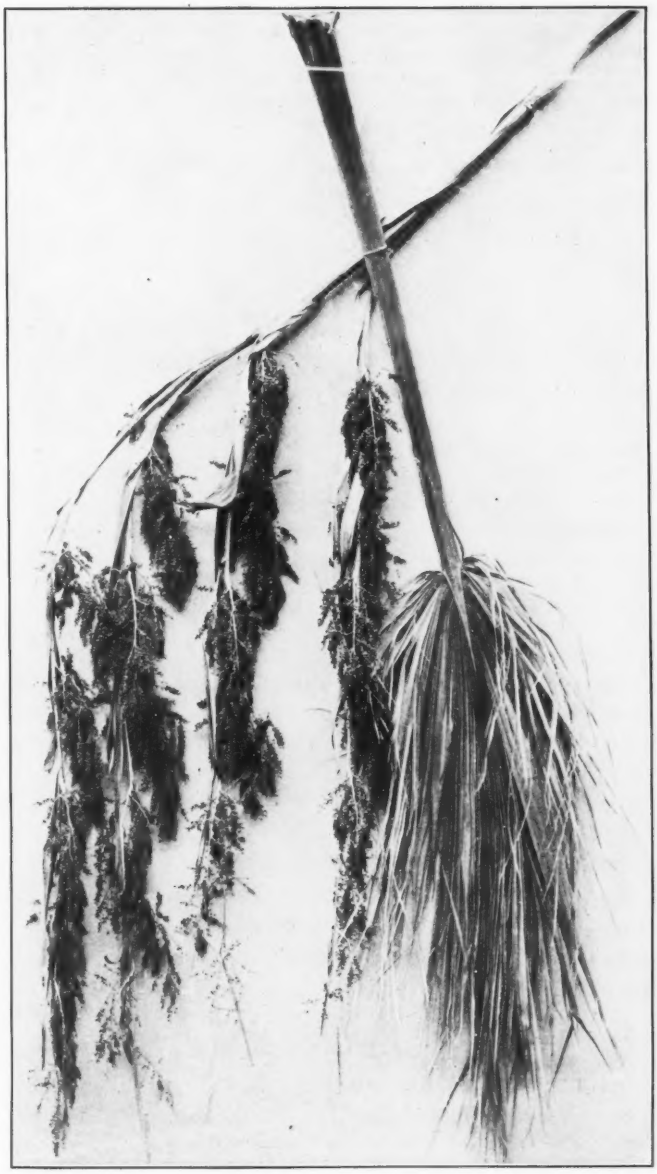

FIG. 7.—Leaf and very young fruit of *W. filifera microsperma;* from a tree in the gardens of Marquise Corsi, Sesto, near Florence, Italy.

8–10^{dm} in diameter, the folds 75–80, deciduously tomentose toward the base beneath, cleft little more than one-third toward the base, not filiferous except for an occasional single filament in the sinuses of some of the folds: peduncles declined, exceeding the leaves; primary divisions 6–8, each bearing 5–10 separated thryses, which are mostly exceeded by their narrow, deciduous, chartaceous bracts; flowers nearly sessile: calyx tubular-campanulate, 3^{mm} long, the short rounded lobes lacerate: tube of corolla 3^{mm} long, its lobes erect, narrowly lanceolate, 6–7^{mm} long: filaments subulate, 3^{mm} long, the versatile anthers 4^{mm} long: seeds broadly ovate, 6–7 by 5^{mm}, somewhat rugose on the raphal face.

Described from cultivated trees growing in San Bernardino and Riverside, California; probably indigenous in northern Lower California.

This palm is readily distinguished from *W. filifera* and its varieties by its slender trunk and smaller and less deeply divided leaves, which are without filaments and on shorter petioles. It is a tree of rapid growth and has been extensively planted in recent years in southern California, under the mistaken name of *W. robusta*, the true *W. robusta* being known as *W. filifera*. According to the report of a reliable dealer, the seed from which the older trees were grown was procured from indigenous groves in cañons, running to the sea, on the coast of Lower California, somewhere between the international boundary and Ensenada. Cultivated trees, which now have been fruiting for a number of years, are the present sources of the commercial seed. Much has been gathered from two noble trees, among the oldest in cultivation, which ornament the lawn of Mr. D. W. McLEOD, of Riverside.

4. WASHINGTON SONORAE Watson, Proc. Am. Acad. **24**:79. 1889; **25**:136. 1890.—*Fig. 11.*

This species is readily separable from the others by the obtuse juncture of the petiole with the blade. I have seen only young plants, and their leaves are very abundantly filiferous.

The type station is given by WATSON as "in secluded cañons in the mountains about Guyamas." Dr. E. PALMER, the collector of the type specimens, informs me that the trees grew "in great quantities, and of great size, in the deep cañons running into the Gulf of California, far away from Guyamas." Dr. WATSON subsequently identified as of this species certain specimens collected by Dr. PALMER at La Paz, in Lower California, and on the opposite side of the gulf. The trees in cultivation have been grown, probably exclusively, from seed collected in San José del Cabo, in the same region of Lower California.

The natives of the Cape region recognize three distinct forms of *W. sonorae*. Two of these—"Palma Blanca" and "Palma Colorada"—are distinguished by

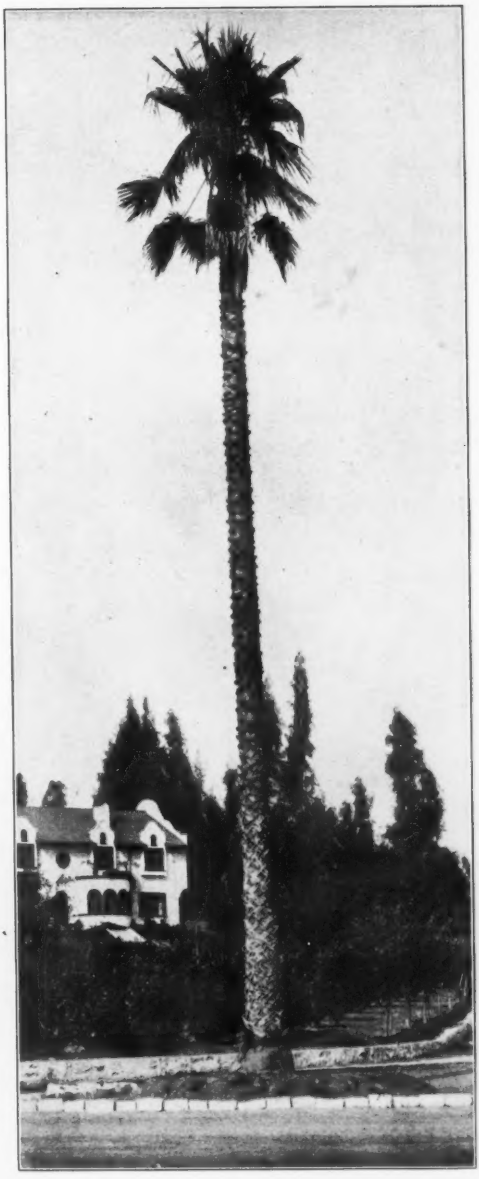

FIG. 8.—*W. gracilis* Parish; Victoria Avenue, Riverside, California. This tree is about 25 years old and 18^{m} high; its circumference at 5^{dm} from the ground is 15.75^{dm}; the leaves have been removed from the trunk.

the white or red color of the woody fiber of their trunks. The third—"Palma Nigra"—is said to be a smaller tree, growing at higher altitudes, where winter snows are not infrequent. Dr. FRANCESCHI, to whom I am indebted for this

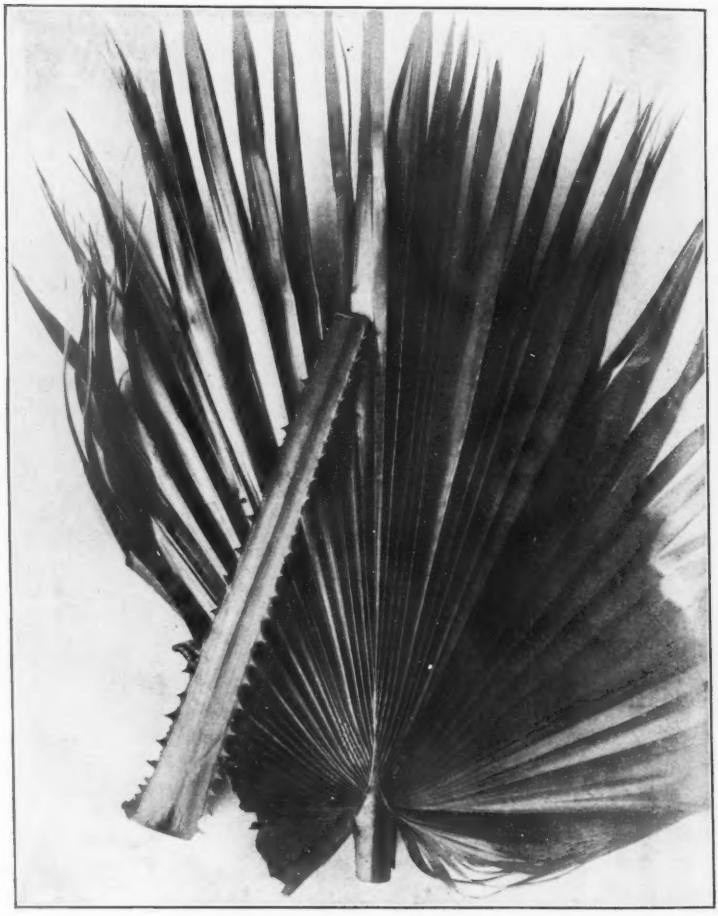

FIG. 9.—Leaf of *W. gracilis*, from a tree at the Santa Fé railway station, San Bernardino, California.

information, has grown many plants, at Santa Barbara, from seeds of each of these forms, but finds no differences in the young trees, nor am I able to detect any in the specimens he has kindly sent me.

FRUIT AND SEED OF WASHINGTONIA

The fruit of Washingtonia is a small oblong drupe, black at maturity, with a thin, sweetish, rather dry pulp. The seed is brown, oblong to oblong-ovate, flattened, excavated or somewhat wrinkled on the raphal face. The first of these raphal characters seems to belong to *W. filifera* and its variety *microsperma*, the second to *W. filifera robusta* and *W. sonorae*, and the last to *W. gracilis*. To determine whether these characters are constant requires the study of extensive series of authentic seeds from varied sources. For this the material is not at hand. *Fig. 12*, for which I am indebted to Dr. BECCARI, represents the seed as at present understood.

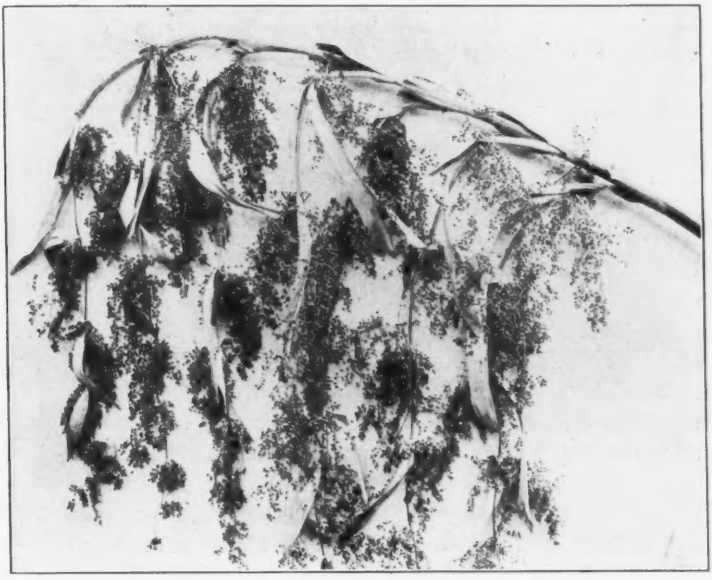

FIG. 10.—Panicle of *W. gracilis*, just setting fruit, from a tree on the lawn of Mr. D. W. MCLEOD, Arlington Avenue, Riverside, California.

ADDITIONAL NOTES ON W. FILIFERA ROBUSTA

WENDLAND'S *Washingtonia robusta*, long considered an obscure if not, indeed, a mythical tree, is in reality the one with which we have

the fullest acquaintance. The type source of *W. filifera* is unknown, the native home of *W. gracilis* remains unvisited, the haunts of *W. sonorae* seldom have been penetrated, but many botanists have stood beneath the groves of the desert *W. robusta*, and it has long been familiar in cultivation in southern California.

Distribution.—Its distribution appears to have been determined by the boundaries of the great lake which, in the not very distant past, occupied the central depression of the Colorado Desert. We may reasonably suppose the shores of this ancient lake to have been enlivened, here and there, with groves of stately palms. A few venerable trees still linger near the upper shore line of this vanished sea, gaunt and ready to perish, and without offspring to succeed them; but the most have retired to the cañons of the surrounding mountains. Here they find congenial homes along the few and feeble streams, by some scanty spring, or narrow oasis moistened by alkaline percolations. The necessity of soil moisture is the governing factor in their distribution.

The most extensive groves occupy a tract of strongly alkaline soil along the foothills some ten miles north of Indio, and extending up some of the neighboring washes. This belt may be considered the center of distribution. The finest grove occupies, for a mile or more, the narrow Palm Cañon, on the opposite side of the desert at the base of San Jacinto Mountain. Here hundreds of fine trees fill the sandy bed of the stream or cling to the rocky bases of its steep sides. The older trees are still vigorous, and there are abundant younger ones of all sizes. It is convenient of access from the little village of Palm Springs.

Most of the cañons at the desert bases of San Jacinto contain palms. A few grow in the cañon of the Whitewater, which is the western limit of the species. Its southern outpost is probably at Carrizo Creek; a few trees at Corn Springs mark its northern limit, and none are known east of Frink's Station.

Duration of the leaves.—It is seldom that one sees a desert palm, either indigenous or cultivated, that has not been marred by human agency. A naked trunk, crowned with living leaves, beneath which is a mass of dead ones deflexed, is not the natural aspect of the tree. The effete leaves, were they not artificially removed, would conceal

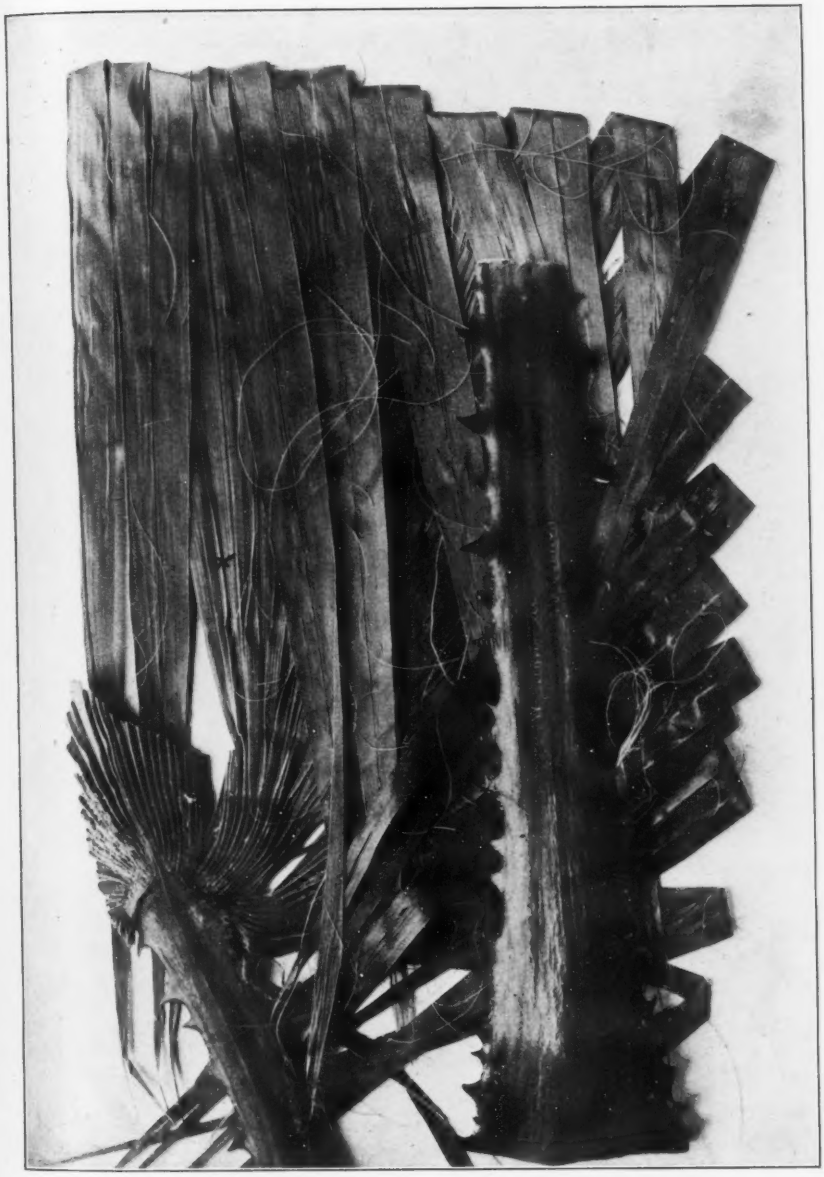

FIG. 11.—Leaf of *W. sonorae* S. Watson, from a tree in the Botanical Garden, Palermo, Italy.

the trunk, at least for the greater part of its length, beneath a gray thatch, an ideal protection against the parching air of the desert. The dead leaves are usually kept cut away from cultivated trees, while it is almost impossible to find mature indigenous palms from which the leaves have not been repeatedly burned. To so burn them was the immemorial custom of the desert Indians, and it has been erroneously alleged that in this they were influenced by a superstitious motive—the making of an offering by fire to the spirits of the dead. In fact their purpose was purely utilitarian, namely, to facilitate the gathering of the fruit, and, as they believed, to increase the fruitfulness of the trees. That the trees survive these repeated burnings is evidence of their wonderful vitality.

The functional life of a leaf is about one year. How long the dead leaves would remain attached to the trunk if undisturbed cannot be stated; probably for a very long period. There is a row of trees in San Bernardino fully 10^{m} tall from which the leaves have never been removed, and the lowest are over twenty-five years old and still firmly attached to the trunk. In a secluded nook of San Jacinto Mountain there is reported to be a group of three majestic palms, 20^{m} or more in height, whose trunks are clothed with a dense leaf-thatch from crown to base; their age cannot be less than a century. From the burned trees the leaves eventually fall off in great masses, the bases of the petioles seeming to have been violently wrenched loose, and not to have naturally separated, as with deciduous leaves.

Aboriginal uses.—The habitations of the desert Indians were mere shelters, but naturally palm leaves, when easily procured, were utilized in their primitive construction. Strands split from the leaves were convenient for tying, and it is said were sometimes used for the spiral coil with which they built up their baskets (MERRIAM :03).[11] They were also used in building the characteristic granaries used by these Indians for storing the various seeds used by them for food.

Of these food supplies the fruit of the palm was an important part. It was eaten fresh, and also dried for preservation. A favorite method of preparing the dried fruit was by triturating it with water

[11] The stems of a grass, *Epicampes rigens*, was the material commonly used for this purpose. I have never seen a basket in the construction of which palm leaves had entered.

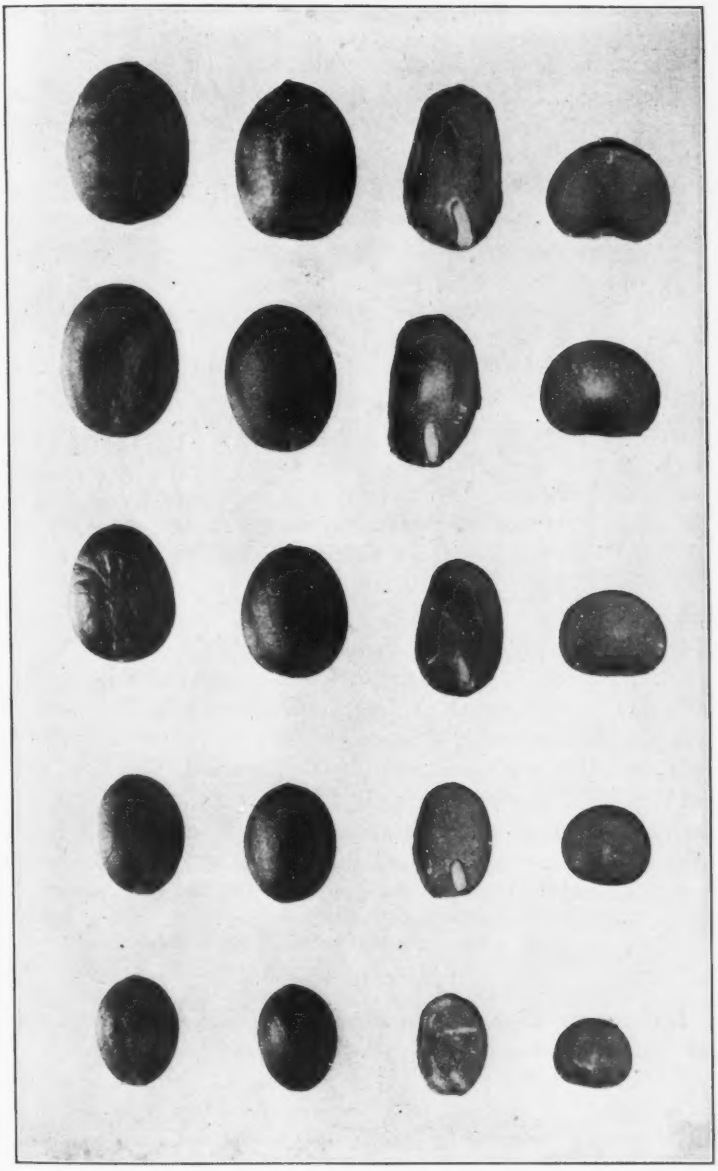

FIG. 12.—Seeds of Washingtonia; all ×3; *1* (bottom row), *W. filifera microsperma*, 4.8–5.8×3.5–4mm; *2*, *W. filifera*, 5.8–6×4–4.5mm; *3*, *W. gracilis*, 6–7×4.8–5.3mm; *4*, *W. filifera robusta*, 7–8×5.5–6mm; *5*, *W. sonorae*, 7–8.5×5.5–6.5mm.

in a stone mortar until a pulpy mass, rich in saccharine properties, was produced. The seeds were then separated and the pulp was thickened with meal made from pounded "chia" (Salvia), or grass seed, or pine nuts. The bony seed itself was pounded into meal, which Dr. EDWARD PALMER ('78), who seems to have tried it, pronounces "not inferior to cocoanut," a statement which may be accepted with some reservation. The terminal bud also was baked and eaten. The Coahuilla name of the palm is *Mau-wal*. Each grove was the property of a particular clan, to whom alone belonged the right to gather the fruit.

An insect enemy.—The desert palm is not known to be infested by any parasitic fungus, or to be subject to any bacterial infection. Its sole enemy is the larva of a Bostrychide beetle, *Dinapate Wrightii* Horn, the only species of the genus. The female oviposits at the base of the living leaves, whence the larva bores downward through the trunk, its continually enlarging galleries becoming at length 18^{mm} in diameter. These are tightly packed, for the most part, with rejected gnawings. The larval life of the insect is three or four years, perhaps even longer. The mature beetle has a length of fully 5^{cm} and is the heaviest North American coleopter.

The number of contemporaneous larvae that may inhabit a single trunk has been estimated as high as 200 or 300; but Mr. W. G. WRIGHT, who discovered the beetle, and who has assiduously investigated its habits, is of opinion that it would probably not exceed 50. But even such a horde of huge and voracious grubs, in their comparatively long life, might riddle a whole trunk with their galleries. They seem not to work any great destruction to the groves, however; in fact, the only evidences of their presence to the ordinary observer are the exit holes in dead trunks.

ACKNOWLEDGMENTS

In the preparation of this account I have been greatly aided by information communicated by several friends. I especially desire to record my thanks to Dr. ODOARDO BECCARI, the distinguished palmographer of Florence, Italy, for valuable notes regarding the Washingtonias cultivated in Europe, and for the photographs illustrating them. Other photographs were kindly made for me by Mr.

W. G. WRIGHT. For copies or abstracts of papers not otherwise accessible to me I am under obligations to Mr. H. M. HALL, of the University of California, Miss MARY A. DAY, librarian of the Gray Herbarium, Dr. J. N. ROSE, of the National Herbarium, and Mr. C. E. FAXON, of the Arnold Arboretum. Dr. WELWOOD MURRAY, for many years a resident of Palm Springs, has favored me with some notes on the use of the palm by the Indians.

SAN BERNARDINO
CALIFORNIA

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ARAUCARIOPITYS, A NEW GENUS OF ARAUCARIANS

EDWARD C. JEFFREY

(WITH PLATES XXVIII–XXX)

Among the coniferous remains discovered in the Cretaceous deposits of the Androvette pit, Kreischerville, Staten Island, are certain leafless twigs, bearing spirally arranged scars. In most cases the twigs in question are decorticated as well as deprived of their appendages; in fact, in all the best-preserved material this is the case. An examination of the internal structure of these remains showed that they were Araucarian in their affinities; but possessed deciduous shoots, similar to those occurring in Pinus. The deciduous shoots seem to have been of seasonal duration only. The branches of the type described above were found in association with impressions of the deciduous leaf-fascicles of Czekanowskia, a supposed but doubtful representative of the Ginkgoales. It is not improbable that the two sorts of remains belong to each other, although it is impossible to more than infer that such is the case at the present time.

Fig. 1 represents a transverse section through a rather well-preserved stem of our species, which we propose to call **Araucariopitys americana,** for reasons to be stated later. The lower right-hand portion of the section is in a bad state of preservation. There are two marked indentations of the surface of the decorticated stem; these mark the positions of two deciduous leafy shoots. The indentation on the extreme right of the figure occurs in the less well-preserved region, so that the topography of the relation of the deciduous shoot to the supporting axis is not clear. The indentation on the upper left-hand part of the surface of the stem corresponds to a short shoot, which is not cut axially by the plane of section. In the well-preserved part of the wood it is obvious that there is but a single annual ring present. A noteworthy feature of the wood is the presence of a tangential row of traumatic resin canals. These traumatic canals are very common

[1] Contributions from the Phanerogamic Laboratories of Harvard University, No. 11.

in this species, occurring in nearly half the specimens in our possession. It would thus appear that the species was very easily stimulated to the formation of traumatic resin ducts.

The pith is not well shown in *fig. 1* on account of the partial decay of the specimen. In *fig. 3* it appears more clearly, and it is possible to distinguish that there are certain dark areas in it, which correspond to islands or nests of sclerotic cells, similar to those which are found in the medulla of the Cretaceous genus Brachyphyllum. The pith is relatively large in size, exceeding in its proportions that found in living Cupressineae. *Fig. 3*, which was made from a section higher up in the branch than that which supplied *fig. 1*, shows on the upper right-hand side the presence of a small portion of the cortex and bark *in situ*. In the cortex are present, although this feature is not apparent in the figure, the same islands or nests of sclerotic tissue which are found in the medulla.

Fig. 2 shows the cross-section of another less well-preserved stem, which has lost part of its woody tissues, but still retains a considerable portion of its bark. The apparent cracks in the wood represent rows of resin canals, which the magnification is not sufficient to make apparent. *Fig. 4* illustrates a part of the same stem as that shown in *figs. 1* and *3*, under a higher magnification. The row of traumatic resin canals can be particularly well made out here and also the sclerifications, which appear as dark spots in the pith.

Fig. 5 shows a portion of the section figured in *fig. 1*, under a considerable degree of magnification. The absence of resiniferous cells, such as are a feature of the wood of the Cupressineae, can be made out. A number of rounded cavities appear in the wood, which are the traumatic resin canals. By their rounded contour, they more nearly resemble those of the Abietineae in aspect than those of any other of the Cretaceous Araucarineae which we have studied. The resin canals are surrounded by one or more layers of parenchyma cells, which appear to be devoid of contents. Often there is present in the lumen of the canals themselves a dark-hued substance, which is in all probability a fossil gum or mucilage, since it is not soluble in any of the numerous solvents of resin used hot in the process of preparing the material for sectioning. This substance apparently corresponds to that described as present in the traumatic resin

canals of other Araucarian lignites from various levels of the Cretaceous.[2]

Fig. 6 shows a tangential longitudinal section of the wood of our species, through the region of the traumatic resin canals. It is to be noted that these are more numerous than is the case with normal resin canals, and are somewhat constricted at intervals, both features to be found in the wound-canals of the Abietineae. In the region of disturbance shown in *fig. 6*, the rays vary greatly in height, being composed of from one to many cells. *Fig. 7* shows the left-hand portion of *fig. 6*, more highly magnified. In this figure the end walls of the ray cells, which appear in face view, are strongly pitted, a feature found in no other living or fossil Araucarian, which has been described, but very characteristic of the Abietineae. Both the end and horizontal walls of the ray cells in Agathis and Araucaria, for example, are smooth, and this statement equally holds for the numerous species of Mesozoic Araucarians which it has been possible to study in the Androvette deposits. Our present species differs, then, from all other Araucarians, living or extinct, in the presence of abundant pitting on the terminal and horizontal walls of the cells of its medullary rays. The cells constituting the rays are entirely parenchymatous and there are no tracheidal cells present, such as occur in the rays of certain species of living Abietineae. *Fig. 9* shows with sufficient clearness the strongly pitted horizontal wall of the ray cells in our species.

In *fig. 8* is seen a longitudinal approximately radial section of the wood in Araucariopitys. The magnification is scarcely sufficient to show the araucarian radial pitting of the tracheids. This section shows very well, however, the constriction of the traumatic resin canals at intervals, which Professor PENHALLOW, in the case of the traumatic and normal resin canals of certain Abietineae, has interpreted as an indication of the derivation of the continuous system of resin canals, present, for example, in Pinus, from the union with each other of a number of originally isolated resin spaces or cysts.[3] This view, as will be shown on another occasion, can scarcely be accepted.

[2] JEFFREY, E. C., The wound-reactions of Brachyphyllum. Annals of Botany **20**:383–394. *pls. 27, 28.* 1906.

[3] PENHALLOW, D. P., The anatomy of the Coniferales. Amer. Nat. **38**:243 ff. 1904.

Fig. 10 shows the structure of the pith in our species. It will be seen that it is traversed at intervals by diaphragms of sclerenchymatous cells, which strongly recall those to be found in Abies, Picea, and certain hard pines. The stone cells are arranged in longitudinal rows, as if they had been formed by the transverse divisions of a horizontal series of mother cells, as has been described in certain Calamites and Equiseta. *Fig. 11* illustrates the character of the radial pitting in our species. It will be seen by examination of the pits on the left of the figure that some of them are in intimate contact and are mutually flattened, in the manner characteristic of the radial pitting of *Araucarioxylon* Kraus. There is a clear distinction from the typical condition in Araucarioxylon, however, in the fact that not all the pits are mutually flattened, but some of them are rounded in contour, as in the wood of the Abietineae. The pitting in our species is thus transitional between the types characteristic of Araucarioxylon and Pityoxylon or Cedroxylon. In the general memoir on the Conifers of the Androvette Cretaceous deposits, it has been proposed that woods of a type transitional between the modes of radial pitting found in the Araucarineae and Abietineae should come under a new genus Brachyoxylon, taking the wood of the genus Brachyphyllum as the type. Our present species, however, can scarcely be put under Brachyoxylon, since in the latter the terminal and horizontal walls of the ray cells are smooth as in the living Agathis and Araucaria and their near allies of the Mesozoic. In the species under discussion, by contrast the terminal and horizontal walls of the ray cells are both strongly pitted, as is typically the case in the Abietineae. If other species of lignites are subsequently discovered which agree with that under discussion in their essential features, it will probably be well to establish the name Araucariopityoxylon or some convenient abbreviation of it for their reception. So long as the type is represented by a single lignitic species, however, the name Araucariopitys will suffice both for the branches and the wood. On the other hand, if it is proved subsequently that Araucariopitys represents the branches of Czekanowskia, as we strongly suspect to be the case, both names will have to be merged in Czekanowskia.

In *fig. 12* is shown a highly magnified view of the radial pitting of the species under discussion. The field is so chosen as to include

mainly tracheids, showing the araucarian type of pitting. Occasionally a tracheid may be found in longitudinal sections of our species, broad enough in its terminal region to accomodate a double row of pits, in which case the phenomenon of alternation as well as flattening may be observed, although even the biseriate pits are sometimes found to be opposite as in the Abietineae. It may be questioned by the reader whether the evidence afforded by the pitting alone is strong enough to decide the Araucarian affinities of the genus we have been describing. We have no inclination to deny the propriety of such a doubt, but we consider it to be removed by the fact that the large number of presumably transitional Araucarians found in the form of well-preserved leafy branches in the Androvette deposits were accompanied by numerous associated cone-scales, which, where they did not obviously belong to Pinus, were also Araucarian and of a transitional type of organization. For a full discussion of this matter the reader is referred to the joint memoir already cited.

Fig. 13 illustrates the short shoot of Araucariopitys as seen in tangential section under low magnification. The brachyblast is present in the upper part of the field. Below it there is a scarcely perceptible disturbance in the arrangement of the tracheids, indicating the position of the foliar trace, to which the short shoot is axillary. It is apparent, from the topography of the tangential section of the wood, that the axillating leaf was better developed in Araucariopitys than is generally the case in Pinus, where the subtending foliar organ is usually obsolete or has degenerated into a mere scale. There are of course in Pinus certain exceptions to this statement in the case of seedlings and the shoots growing out of injured branches. In *fig. 14* is represented a more highly magnified view of the section of the same short shoot shown in *fig. 13*. *Fig. 15* represents a radial section through the axis of the short shoot, which at the same time includes a part of the woody cylinder and the pith of the parent axis. In *fig. 16* is seen a transverse section through the main axis at the level of exit of one of the brachyblasts. It is easy to determine from the sections just described that the woody cylinder of the short shoot projects little if at all beyond the surface of the wood of the main axis. *Figs. 12–17* have all been made from another specimen than that which furnished *figs. 1, 3, 4, 5*. *Fig. 17* presents a somewhat magni-

fied image of the transverse section of the axillating leaf trace as seen in longitudinal section of the axis. There is obviously a considerable disturbance in the arrangement of the tracheids of the axis.

All the available specimens of our fossil showing the bark in place are unfortunately badly preserved. They confirm the conclusion, however, that Araucariopitys possessed deciduous shoots comparable with those of living pines and at the same time was an araucarian Conifer. The condition of preservation in the corticated specimens makes it possible to observe that the deciduous shoots have already fallen in branches which show but a single annual ring and are subtended by definite absciss layers occurring in the outer cortex. There are no peridermoid tissues present except in the limited areas immediately opposite the deciduous shoots.

It will be obvious to the reader that in the coniferous branches to which we have assigned the name Araucariopitys, there are features present which combine in a remarkable degree the anatomical characteristics of both the Abietineae and Araucarineae. The radial pitting of the tracheids, for example, as has been shown above, is clearly transitional between the two orders. The rays tend more strongly to the abietineous side. The wound-reactions of our Conifer are more like those of the Abietineae than are those of any other known Araucarian. Finally, the genus was characterized by the possession of deciduous shoots. It will be obvious from the enumeration of the features that in the species under discussion we have a strong araucarian endowment with a nearer approach to abietineous structure than has been found in any Araucarian living or extinct. Since this is the case, the name Araucariopitys, etymologically significant of the double affinities, seems appropriate.

CONCLUSIONS

It appears from the description given above that there are present in the Cretaceous deposits of Kreischerville, Staten Island, N. Y., certain branches with deciduous lateral shoots, resembling in their relation to the axis the brachyblasts in the abietineous genus Pinus. Further, it is apparent that in spite of the possession of deciduous shoots, the branches in question belong to an araucaraian Conifer of archaic type, as is shown by their anatomical structure. The wood

of these shoots presented the wound-reactions of the Abietineae, radial pitting of the tracheids transitional between the Abietineae and Araucarineae, and the ray structure of the Abietineae. It is moreover probable that leafy shoots known under the generic appellation of Czekanowskia belonged to our species, since the former occur in impressions in association with these remains.

It appears clear that in Araucariopitys we have to do with a genus transitional in its characters to a marked degree and nearer to the Abietineae than any other known araucarian genus living or extinct. The existence in the Mesozoic of types like Araucariopitys, Brachyphyllum, Geinitzia, etc., combining in so many ways abietineous and araucarian characters, does not make it easy to accept as correct the position recently adopted by Professor SEWARD[4] that the Araucarineae are distinct from, and without immediate affiliations with, the other coniferous orders. It is indeed not difficult to show that the aberrant forms which represent the Araucarineae in the existent flora are sufficiently different from the Abietineae and most of the other coniferous families; but such a conclusion cannot now be projected into the past, in the face of our recent fuller knowledge of the structural features of the araucarian flora of the Mesozoic.

Since it must apparently be admitted that in the Mesozoic the abietineous and araucarian Conifers were not so clearly separated from each other as the living representatives of those families are, the question arises, which of these two admittedly ancient families lies nearer to the ancestral stock? Professor SEWARD and others have argued, from the rich luxuriance of the araucarian flora in the Cretaceous and even earlier periods of the Mesozoic (a luxuriance which our own studies, as described in the monograph already referred to, only serve to emphasize), as compared with the comparative poverty of the abietineous display, for the superior antiquity of the araucarian Conifers. Such an argument appears, however, to be fallacious. It would be just as logical to assume that at any given period the richly developed crown of a forest tree was its oldest portion. All the evidence goes to show that the Araucarians were indeed the crown of the coniferous genealogical tree during the Mesozoic, but

[4] SEWARD, A. C., and FORD, S. O., The Araucarieae, recent and extinct. Phil. Trans. Roy. Soc. London B. **198**:305–411. *pls. 23, 24.* 1906.

in the changes which ushered in the Tertiary the crown was almost completely destroyed and that a lower more ancient and overshadowded branch, the Abietineae, became a new "leader" and developed luxuriantly.

Concerning the derivation of the Araucarineae from the Abietineae in the beginning of the Mesozoic period, evidence has rapidly accumulated of late. Reference has been made above to the striking abietineous characteristics of the older Araucarians. It has been pointed out that the wound-reactions of the older Araucarineae are a strong indication of their abietineous derivation. Further, although the older Araucarians show striking transitions in their pitting toward the Abietineae, even the most archaic structurally known abietineous type, Prepinus, shows no tendency whatever toward the araucarian form of bordered pit. In the case of Prepinus just referred to, we are moreover forced to the conclusion that we have to do with an extremely ancient coniferous type, since the foliar bundles show an abundant development of true centripetal wood as distinguished from mere transfusion tissue. Further, the leaf traces are completely surrounded by a complicated double sheath of transfusion tissue, which has its exact counterpart in certain Cordaites but not elsewhere. Prepinus, in other words, manifests a nearer affinity to the ancestral Gymnosperms than any other known Conifer, and at the same time is clearly related to the Cretaceous species of Pinus, as is shown in the article cited. An additional argument for the superior antiquity of the Abietineae is afforded by the morphology of the female cone. It is true that Professor SEWARD, in the memoir cited above, has questioned whether the same morphological explanation can be offered of the female cone in the Abietineae and Araucarineae, in view of what he considers to be the slight degree of relationship between them. That the two families must be regarded as somewhat nearly allied we have tried to show above. If it be admitted that they are closely connected it follows that a common explanation of their ovulate strobilus should be possible. If we accept the generally approved explanation of the double cone-scale present in the female cone of the Abietineae, namely, that the upper ovuliferous scale is an axillary structure of shoot value subtending the sterile bract, then we are almost driven to regard the single cone-scale of the Araucarineae with

its *double* system of bundles as having resulted from the *fusion* of the two organs present in the Abietineae. If this be granted, it is not easy to deny to the Abietineae a superior antiquity.

SUMMARY

1. Araucariopitys is an araucarian Conifer found in the Middle Cretaceous Clays of Staten Island, N. Y.

2. Its structure and its association with impressions of the leaf-fascicles of Czekanowskia make it possible that it constitutes the branches of that genus, which in such a case cannot be regarded as belonging to the Ginkgoales.

3. Araucariopitys was characterized by the possession of deciduous shoots, which apparently persisted for a single year; by the characteristic radial pitting of its tracheids, transitional between true araucarian pitting and that found in the Abietineae; by rays differing from the araucarian type and approximating the abietineous type; by the formation of traumatic resin canals closely resembling those found in the Abietineae.

4. Araucariopitys, although unquestionably araucarian, was nearer in structure to the Abietineae than any other known araucarian genus living or extinct, and has been named in accordance with this fact.

5. Araucariopitys supplies additional evidence for the derivation of the Araucarineae from the Abietineae.

PHANEROGAMIC LABORATORIES
HARVARD UNIVERSITY

EXPLANATION OF PLATES XXVIII–XXX

PLATE XXVIII

FIG. 1. Transverse section of stem of *Araucariopitys americana*. ×30.

FIG. 2. Transverse section of another specimen of the same. ×18.

FIG. 3. Transverse section of stem of *Araucariopitys americana* from the same specimen as *fig. 1*. ×24.

FIG. 4. Transverse section of part of the same. ×40.

FIG. 5. Transverse section of the same to show the traumatic resin canals. ×180.

PLATE XXIX

FIG. 6. Tangential longitudinal section of *Araucariopitys americana*. ×100.

FIG. 7. Tangential section of the same. ×180.

FIG. 8. Longitudinal approximately radial section of the same. ×40.

FIG. 9. Radial section of the same, showing structure of the ray. ×500.

FIG. 10. Section of the medulla of the same. ×40.

FIG. 11. Longitudinal radial section of the same. ×180.

PLATE XXX

FIG. 12. Longitudinal section of the tracheids of the same to show Araucarioxylon pitting. ×500.

FIG. 13. Tangential section of main axis of Araucariopitys, showing the presence of a short shoot and its axillating leaf trace. ×25.

FIG. 14. The short shoot of the same. ×40.

FIG. 15. Radial section through the deciduous shoot of the same. ×40.

FIG. 16. Transverse section of wood of Araucariopitys, showing the base of the deciduous shoot in longitudinal section. ×40.

FIG. 17. Tangential section of wood of Araucariopitys, showing the trace of the axillating leaf in transverse section.

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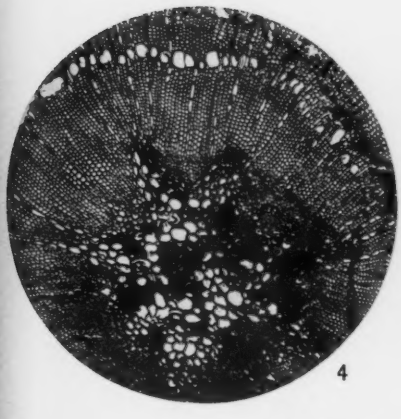

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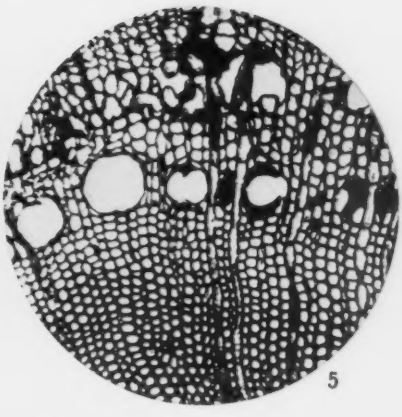

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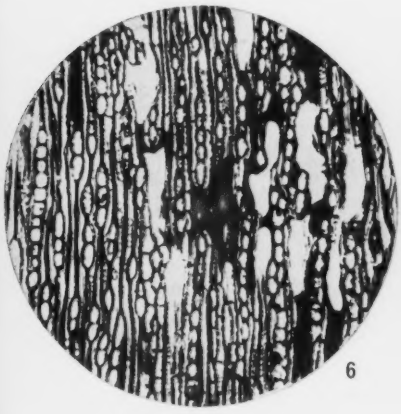
JEFFREY on ARAUCARIOPITYS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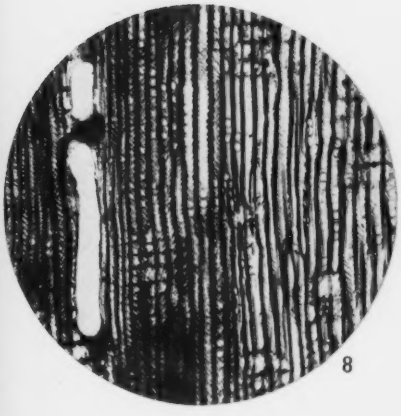
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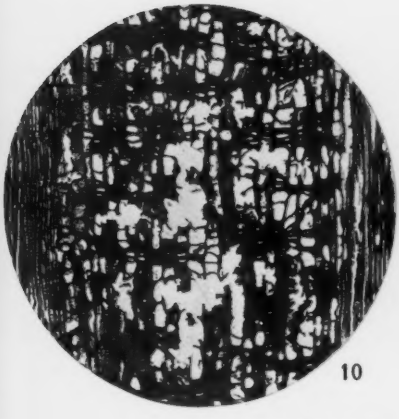
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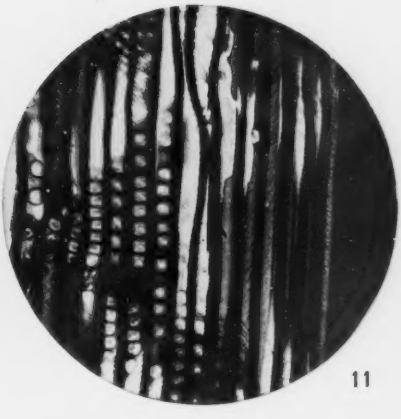
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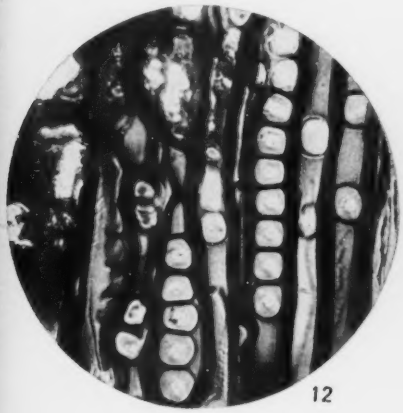
JEFFREY on ARAUCARIOPITYS



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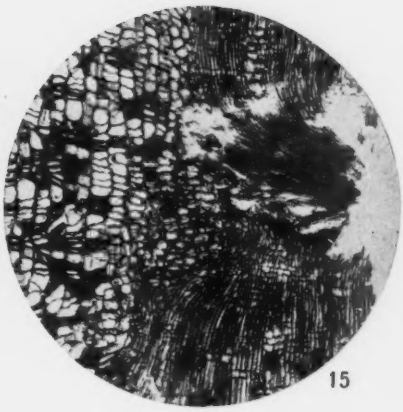

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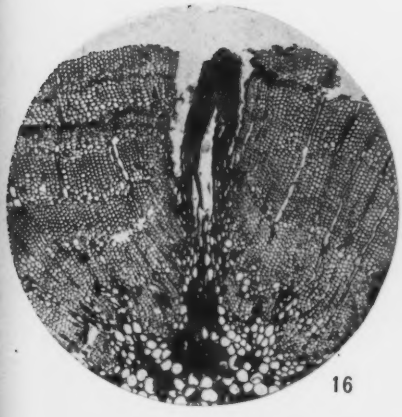

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17

JEFFREY on ARAUCARIOPITYS

DIFFERENTIATION OF SPOROCARPS IN AZOLLA

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 105

WANDA M. PFEIFFER

(WITH PLATES XXXI AND XXXII)

A summary of the work on Azolla up to 1844 may be found in GRIFFITH'S (1) account of Azolla and Salvinia. Working on *Azolla pinnata*, GRIFFITH began his account with the development of the sporocarps. The earliest stage described showed two sporocarps within a hoodlike involucre. Each sporocarp consisted of a cup-shaped integument and a cellular body, the "nucleus,"[1] which was surrounded by the "integument"[2] and projected from it. Later the "nucleus" elongated and the "integument" grew out so rapidly as finally to inclose it. At a still later stage, simple capitate "filaments"[3] of cells developed about the base of the "nucleus." Up to this point, the development in the two organs had been similar. After this, there might be a development of either the "nucleus" or the cellular projections about its base, but in no case did both continue growth. In cases where the further growth was in the "nucleus," GRIFFITH describes it as developing into the "so-called male organ" of former writers. This organ consisted of an egg-shaped body, bearing a calyptra and containing a large yellow sac capped by a peculiarly stratified body. The first change in the development here was a granular condensation of the materials of the "nucleus." When, on the other hand, only the "so-called female organs" developed, the first step was the appearance of a granular mass in the swollen tip of each of the "filaments," which had appeared in centrifugal order about the base of the "nucleus."

Nearly thirty years later (1873), STRASBURGER (2) wrote *Ueber Azolla*, in which he gave a full account of the mature sporocarps, but said little about their development. He found in the early stages of

[1] From GRIFFITH'S figures it is evident that this "nucleus" is the megasporangium.

[2] The "integument" is the sporocarp wall.

[3] These "filaments" are evidently the young microsporangia, which arise from the massive stalk of the megasporangium.

the megasporocarp a single sporangium developing, and when later he found only one megaspore in the mature sporocarp he naturally inferred that only one sporangium had appeared. Referring to GRIFFITH'S work, STRASBURGER suggested that in case more than one sporangium did appear in a sporocarp, it is more likely that all sporangia should have appeared simultaneously, and that later those about the base of the large central sporangium should have aborted. In the microsporocarp he found microsporangia, in numbers as high as forty, arising from a short "columella." He further said that he found no sign of the club-shaped ending of the columella which MEYEN had described earlier.

In 1889 STRASBURGER (**3**) reinvestigated the subject. According to that account, the primordia of both male and female sori are alike, since in each case there arose at first a short-stalked "macrosporangium" at the apex of the columella. In the "macrosporocarp" this went on developing, but in the microsporocarp its growth was soon inhibited, while from the columella beneath it microsporangial primordia were constantly arising. He suggested that the development of one or the other might depend upon the method of nutrition.

In 1893 CAMPBELL (**4**), referring to *Azolla filiculoides*, wrote:

> For some time each sporocarp rudiment grows by a three-sided apical cell. Next a slight outgrowth is observed near the base of the young sorus, which forms a ring-shaped projection; this is the beginning of the indusium or sporocarp wall. . . . . From this point, the two sorts of sori differ. In the macrosporic one, the apical cell forms at once the body of a single sporangium; in the microsporic it forms a columella, from which latter the microsporangia appear as lateral outgrowths.

In speaking of the megasporocarp he said:

> When the sporangium is about half grown, the outer cells of the very short stalk grow out into short papillae, which apparently are abortive sporangia, as they show divisions which recall the earlier ones in the macrosporangium. Their position corresponds to that of the microsporangia, so that although formed much later than the macrosporangium, it is pretty safe to assume that Azolla is derived from some form in which, as in Salvinia, there are several macrosporangia in the sporocarp. . . . . In the male sorus, as we have already seen, the apical cell of the young rudiment does not form a sporangium, but gives rise to a central columella or placenta from which microsporangia arise laterally, while the end projects as a cylindrical body. This latter was observed by MEYEN, but STRASBURGER seems for some reason to have overlooked it. I found it in all of my sections of the male sorus.

In 1898 GOEBEL (**5**) again investigated the method of sporocarp development in *A. filiculoides*. He accepted STRASBURGER'S later account of the development of the microsporocarp, but in the megasporocarp he found in the later stages of development primordia of microsporangia which had aborted.

In CAMPBELL'S revised edition of *Mosses and ferns* (**6**, 1905), he refers to GOEBEL'S account and states that "in the microsporangial sorus the apex of the receptacle, which probably represents an abortive macrosporangium, forms a columella, from whose base the microsporangia develop." He uses the illustration of the microsporocarp which he had used in the original paper, and shows the columella as a club-shaped body which has little resemblance to a sporangium.

INVESTIGATION

Working on *Azolla carolinicna*, I have traced the development of the sporocarp, paying particular attention to the stage at which microsporocarp and megasporocarp are definitely differentiated.

The youngest stage in which the sporocarp can be readily recognized shows a young sporangium consisting merely of an apical cell and a short stalk, about whose base there is a ringlike projection (*fig. 1*). This sporangium, which holds the central position in the mature sporocarp, is the megasporangium, and is of the ordinary leptosporangiate type.

The projecting ring of cells about the base of the sporangium, by subsequent growth outward and upward, forms the wall of the sporocarp. Growth of the sporangium and growth of the sporocarp wall go on simultaneously, so that by the time the primary tapetal cells are cut off in the capsule of the sporangium, the two-layered sporocarp wall stands almost as high as the sporangium (*fig. 3*). While the development of the capsule of the sporangium has gone on in the regular leptosporangiate way, there has been no such elongation of the pedicel as might be expected. The divisions of the cells of the pedicel, for the most part, have been anticlinal rather than periclinal to the apical cell, so that the stalk is massive, almost as great in diameter as is the capsule (*fig. 3*). Growth in the capsule now continues in the usual way until there is finally a sporangium having one layer of wall cells

and a single layer of tapetal cells surrounding a mass of eight megaspore mother cells in synapsis. There is no trace of an annulus of any sort to be found either at this or any later stage. By this time the sporocarp wall has usually grown up so as almost to inclose the sporangium, while the stalk of the sporangium is likely to be at least four or five cells in diameter (*fig. 4*). While the mother cells are in synapsis, still forming a compact tissue surrounded by a layer of tapetal cells, some of the outer cells of the sporangium stalk enlarge so as to form short papillae (*fig. 5*). These enlarged cells have nuclei larger than those of the other stalk cells, and very soon it becomes evident that each of them is the apical cell of a young sporangium (*fig. 6, mc*). This is the first appearance of microsporangia in the sporocarp. Shortly after the microsporangia appear, the walls of the tapetum in the megasporangium disappear, leaving tapetal nuclei free in a mass of cytoplasm. Surrounded by this tapetal cytoplasm and nuclei, the megaspore mother cells have now separated from each other and become rounded off (*fig. 6*).

In a few cases the growth of the megasporangium is inhibited at this point. When this occurs the megaspore mother cells become shrunken, the tapetal nuclei appear small and more densely granular than in the healthy sporangia, and the cytoplasm takes on a coarse, loosely granular appearance. As this breaking down goes on in the megasporangium, more and more microsporangial primordia appear at its base. This, however, is not the usual course of events. Ordinarily the growth of the megasporangium is not inhibited until after it has passed the spore mother-cell stage.

In almost every case, the megasporangium continues its growth in size while the young microsporangia are developing at its base. Finally the megaspore mother cells divide simultaneously (*fig. 7*) to produce the eight tetrads (*fig. 8*). Even while this division of the megaspore mother cells is taking place, growth in the microsporangia continues, as is readily seen by the fact that cell division sometimes takes place there (*fig. 7, mc*). It is therefore after the formation of the megaspore tetrads (*fig. 8*) that the critical stage in the development is reached.

At this stage the sporocarp wall, which consists of only two layers of cells, has grown up beyond the apex of the megasporangium and

has become almost if not completely closed by the greater elongation of the cells of the outer layer. The general shape of the sporocarp is oval, flattened on one side, and with a beak of enlarged cells at the top. Just inside this wall one often finds unattached filaments of Anabaena lying in the space above the megasporangium. At the base of the sporocarp there arises a massive stalk bearing sporangia. Of these sporangia, the oldest, which holds the central position, is the megasporangium, while the very young microsporangia form one or more whorls about its base. Within the megasporangium wall, of a single layer of cells, is found a mass of cytoplasm in which a large number of small nuclei, of tapetal origin, are lying free, and in the center, surrounded by the most densely granular of this cytoplasm, eight tetrads of spores are lying free from each other.

The question now is whether the megasporangium or the group of microsporangia, all of which are apparently vigorous, shall go on developing. If the megasporangium develops, there will be a megasporocarp; while if the microsporangia develop, there will be a microsporocarp.

In the megasporocarp, thirty-one of the megaspores abort, while one, which usually holds the central position in the sporangium, continues growth (*fig. 9*). The megasporangium increases in size, but there is no further elongation of the stalk, and the young microsporangia at its base cease their growth. As the megasporangium increases in size, it finally completely fills the sporocarp, and the young microsporangia are squeezed down against the stalk until they are hardly recognizable. An abnormal condition, which I found in two megasporocarps, shows two of the megaspores developing, while only thirty abort.

In the microsporocarp, the abortion of the spores in the megasporangium goes a step farther than in the megasporocarp, and we find all thirty-two megaspores aborting. Within the megasporangium the cytoplasm takes on a coarsely granular appearance, the tapetal nuclei are dense shrunken masses, and the megaspores, which may hang together in tetrads or may fall apart as separate spores, are shrunken and shapeless (*fig. 10*). As this abortion goes on, the stalk of the megasporangium elongates somewhat and new microsporangial primordia continue to appear below the older ones, which are

increasing rapidly in size. The microsporangia arise in basipetal succession, have long slender stalks, and each sporangium develops sixteen spore mother cells. As the growth of the stalks in length and of the capsules in size continues, there is a consequent broadening of the sporocarp, which makes of the mature microsporocarp a round body, quite different from the more elongated megasporocarp. By the time the oldest of the microsporangia have reached the mother-cell stage, the megasporangium has usually collapsed, so that unless one happens to get a median section of the sporocarp (*figs. 11, 11a*) it is likely to escape notice. However, I found several microsporocarps in which this collapse of the megasporangium did not occur. In these cases the cytoplasmic contents of the megasporangium had broken down and had to a large extent been resorbed, but the sporangium wall remained turgid, while the cells of the stalk at the base of the sporangium had grown up into the cavity left by the breaking-down of the cytoplasm (*figs. 12, 13*). In one case (*fig. 13*) this growth had continued until the sporangium was nearly filled with vegetative tissue.

DISCUSSION

While GRIFFITH, in 1844, interpreted the megasporangium as a male organ and the microsporangia as female organs, as R. BROWN and MEYEN had before him, he gave an accurate account of the order in which the various structures of the sporocarp appear. Since the appearance of STRASBURGER'S *Ueber Azolla*, writers seem largely to have overlooked GRIFFITH'S work. Doubtless this is due to the fact that STRASBURGER, who worked largely on the very early and the mature stages of the development, without catching the intermediate stages, suggested that probably GRIFFITH'S account would not hold true, since it seemed more probable that the sporangia would appear simultaneously in the megasporocarp as they did in the microsporocarp. It is interesting to note that sixteen years after *Ueber Azolla* appeared, STRASBURGER again gave an account of Azolla, in which he affirms that the primordia of the two sporocarps are alike, since each begins with the development of a megasporangium, which in the microsporocarp soon aborts. It is evident that he no longer thought that the development of sporangia in the microsporocarp is simultaneous, and so his former inference, that probably the mega-

sporocarp is like the microsporocarp in this particular, no longer has any weight.

CAMPBELL, writing four years after the appearance of STRASBURGER'S second paper, has evidently not given close attention to this later account of the development, or he might have been led to make a more careful study of the columella, which he found in all his preparations of the microsporocarp. That this columella actually represents an abortive megasporangium seems not to have occurred to him, although STRASBURGER'S paper would have suggested it. The nearest approach that I found to such a columella as CAMPBELL figures was in the few cases where the vegetative cells of the stalk had grown up into the cavity left by the collapse of the cytoplasmic contents of the megasporangium (*figs. 12, 13*). Any section, except the median, of such a sporangium as that shown in *fig. 13*, would show merely a club-shaped mass of cells; but the median section shows very clearly the remains of the broken-down cytoplasm and nuclei.

To one who has noted the megasporangium beginning to develop in the microsporocarp and then aborting, the interpretation of the sporangial primordia about the base of the megasporangium in the megasporocarp as microsporangia is natural. CAMPBELL, having missed this first point, seems to have missed the second one also, since he infers that the sporangial primordia in the megasporocarp are megasporangial, and so to be compared with Salvinia. He overlooks the fact that in Salvinia the appearance of sporangia is much more nearly simultaneous than in Azolla.

Of all the accounts of Azolla, GOEBEL'S most nearly portrays the course of events as I saw it. Yet even he accepts STRASBURGER'S statement that the abortion of the megasporangium in the microsporocarp occurs early. While at first sight this would seem to be the natural course of events, abortion after the formation of the megaspores really carries the reduction in the megasporangium only one step farther than in the megasporocarp. Long ago STRASBURGER saw cases in the megasporocarp where two spores developed while thirty aborted. This condition, which I have seen a few times, was readily looked upon as a reversion to the condition in which more than one spore developed in the megasporangium. The abortion

of all thirty-two spores in the megasporangium, which holds the central position in the microsporocarp, could be considered a further step in this reduction.

What causes the abortion in one case of thirty, in another of thirty-one, and in a third of thirty-two megaspores, is a question not easily determined. It would seem largely a matter of chance, since there is no external factor or group of factors responsible. Very often megasporocarp and microsporocarp lie side by side, having begun their development from two apical cells which were formed by the division of a single cell, and having continued growth with their surroundings as nearly alike as it is possible to make them. On the other hand, there is no internal condition that we can say, definitely, must be responsible for this. There is of course the possibility that the whole thing is a question of food supply, as STRASBURGER suggested. If there should be some change in the cells of the stalk below the megasporangium making them impermeable to any of the materials which are necessary for growth in the sporangium, the inhibition of growth there would be a natural result. That the food supply thus kept from the megasporangium should then be used for the further development of the microsporangium at the base, seems a plausible supposition. In cases where the cells of the stalk later grow up into the megasporangial cavity, one would have to suppose a regaining of permeability of the cells to food materials. Such changes in the cells from permeability to a given substance to impermeability and back to permeability are quite possible physiologically.

SUMMARY

1. The early development of megasporocarp and microsporocarp are exactly similar. Each begins development with a single megasporangium and a sporocarp wall. When the megasporangium has reached the stage in which eight spore mother cells are in synapsis, some of the outer cells of the stalk enlarge and become the apical cells of young microsporangia. Growth in the microsporangia and megasporangium now goes on simultaneously for some time. The tapetal walls of the megasporangium disappear and the mother cells separate from each other and round off, while the microsporangia at the base continue development, differing in appearance from the

megasporangium only in having long slender stalks and later forming sixteen rather than eight spore mother cells. Before the primary wall cell is cut off in the oldest of the microsporangia, the megaspore mother cells have divided simultaneously to form eight tetrads. Up to this point the development is the same, whether the structure is to be a megasporocarp or a microsporocarp.

2. Further development of the megasporocarp shows one of the thirty-two megaspores continuing growth, while the other thirty-one abort, and the microsporangia at the base of the megasporangium cease growth.

3. Further development of the microsporocarp shows all thirty-two megaspores aborting, while the young microsporangia increase rapidly in size and number. The megasporangium usually collapses so that it is not readily seen in the mature microsporocarp.

This investigation was carried on under the direction of Professors JOHN M. COULTER and CHARLES J. CHAMBERLAIN, The University of Chicago.

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6. CAMPBELL. D. H., Mosses and Ferns, Ed. 2, 412. 1905.

EXPLANATION OF PLATES XXXI AND XXXII

The figures were all made with a Zeiss camera lucida and in all cases, except *fig. 11a*, a Zeiss ocular 4 and Zeiss 2^{mm} objective were used, giving a magnification of 430 diameters after a ½ reduction is made in the reproduction.

Abbreviations: *a*, Anabaena; *am*, abortive megaspore; *as*, abortive megasporangium; *at*, abortive megaspore tetrad; *m*, functional megaspore; *mc*, microsporangia; *mcm*, microspore mother cells; *mm*, megaspore mother cell; *mt*, megaspore tetrads; *s*, sporocarp wall; *t*, tapetum.

PLATE XXXI

Figs. 1–8 give the stages in the development in which the megasporocarp and microsporocarp are similar.

FIG. 1. A very young sporocarp showing the beginning of the megasporangium and sporocarp wall.

FIG. 2. A stage later than *fig. 1*.

FIG. 3. A still later stage; the primary tapetal cells have been cut off in the megasporangium.

FIG. 4. A considerably later stage; the megasporangium is in the mother-cell stage, but no microsporangial primordia have yet appeared.

FIG. 5. A little later than *fig. 4;* the microsporangial primordia are appearing.

FIG. 6. The microsporangia have begun growth; in the megasporangium the tapetal walls have disappeared.

FIG. 7. The heterotypic division of the megaspore mother cells; growth in the microsporangium continuing.

PLATE XXXII

FIG. 8. A still later stage.

FIG. 9. A megasporocarp that can be readily recognized as such; microsporangia have ceased growth.

Figs. 10–13 show conditions found in the microsporocarp.

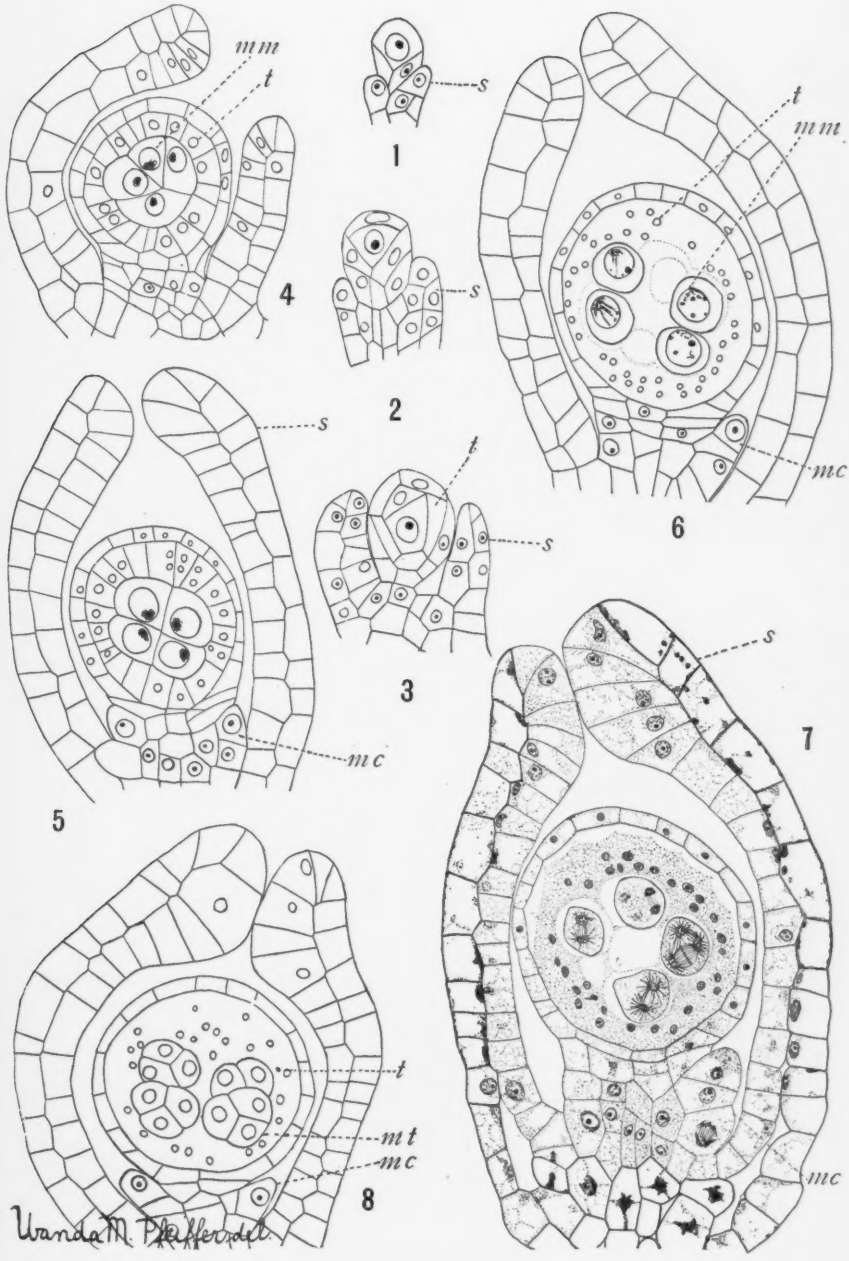
FIG. 10. A microsporocarp of about the same age as the sporocarp in *fig. 9;* the microsporangia are appearing in large numbers.

FIG. 11. The central portion of an older microsporocarp, showing the microsporangium with microspore mother cells, *mcm*.

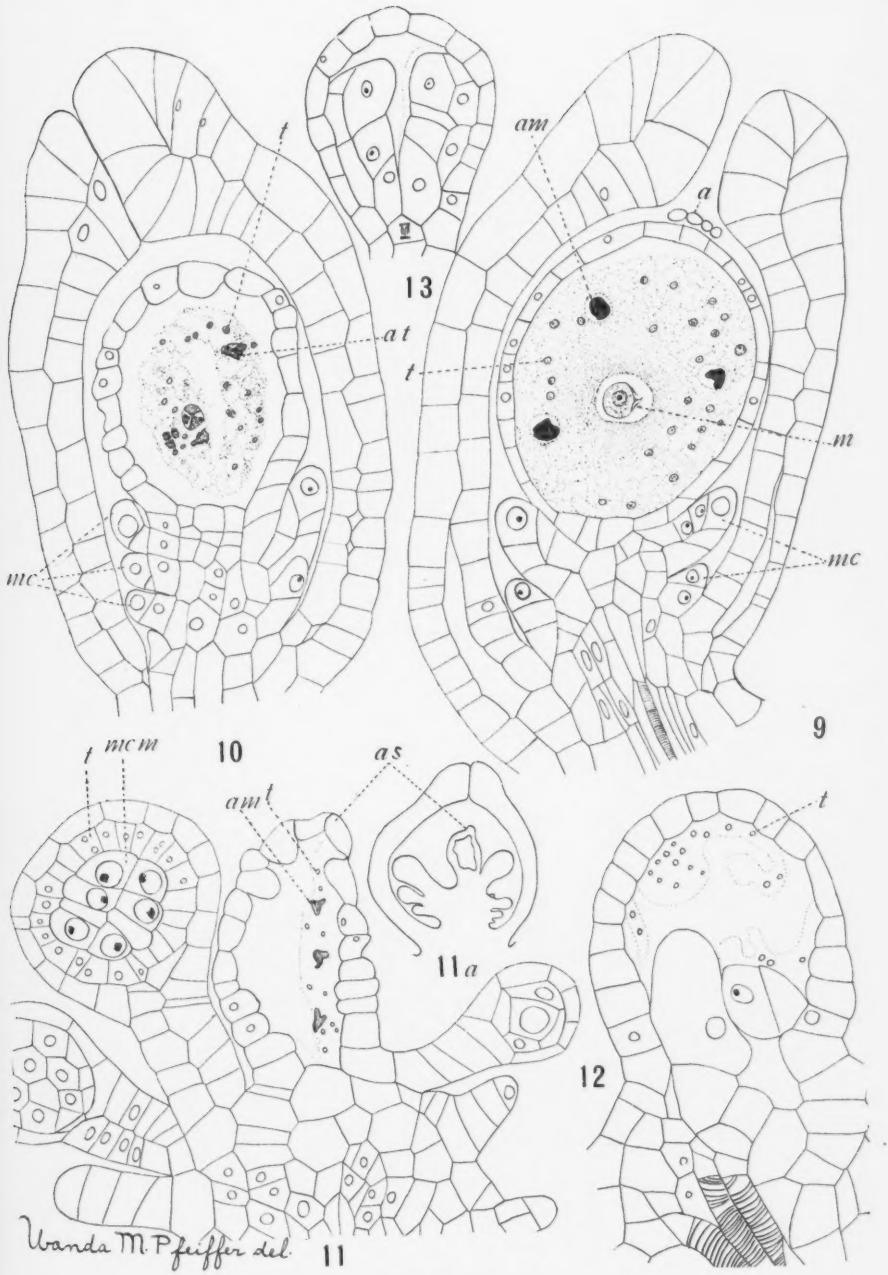
FIG. 11*a*. An outline sketch of the whole sporocarp, a portion of which is enlarged in *fig. 11*.

FIG. 12. One of the abortive megasporangia, into which the cells of the stalk are beginning to grow.

FIG. 13. An abortive megasporangium which has been nearly filled by the upward growth of the cells of the stalk.



PFEIFFER on AZOLLA



PFEIFFER on AZOLLA

CURRENT LITERATURE

BOOK REVIEWS

The nature and development of plants

Dr. CURTIS[1] offers a new book with this title on a basis which must be regarded by anyone attempting to judge its merits. It is not intended as a textbook, says the author, but to give a point of view and to stimulate inquiry. A student who is thoroughly acquainted with *Principles of botany* by BERGEN and DAVIS would discover by examination of this text, as well as by reading the preface, that the book is intended for one of more limited secondary training. That the majority of college freshmen have in one way or another escaped or evaded adequate secondary training makes this effort by Dr. CURTIS very acceptable and practical. The author has used excellent judgment in the selection of material both for discussion and for illustration. So far as possible, plants which the student is likely to see or hear about are used. In order to awaken interest a narrative rather than an expositional style prevails, and the economic significance of several important features of plant life are emphasized in attractive connections. Associated with this style and plan there is apparent an effort to stimulate originality and independent reasoning.

The book is structurally simple, being without even a complete table of contents, but perfectly clear in plan and purpose. The introduction develops a conception of the cell as the unit of structure and of protoplasm as the physical basis of vital phenomena. Part I presents the outer and inner morphology of roots, stems, leaves, etc.; while Part II traces the phylogeny of the four great groups according to the older ENGLER and PRANTL classification. One is at once impressed with the unusual excellence of the illustrations of which there are over three hundred, in most cases original.

If one searches for defects, and this a critic is supposed to do, instances of faulty composition and inaccurate statement may be found. "The elements that compose any substances are held together with great energy owing to their mutual attraction for one another," is an unfortunate slip which disregards the numerous unstable compounds. "The transmission of hereditary characters may be stated as follows. Every feature of a plant or animal which we recognize in distinguishing them is due to hereditary substances derived from the parents." To what extent such a general statement is true cannot be said off-hand, though there is experimental evidence, not overlooked in the text, which renders such a generalization invalid. "The work of respiration is carried on more economically by green plants

[1] CURTIS, CARLTON C., Nature and development of plants. 8vo. pp. 471. *figs. 342.* New York: Henry Holt & Co. 1907. $2.50.

than by animals, since in the animal the CO_2 escapes in the breath as a waste product, while the plant uses the CO_2 during day time for the construction of foods." There is regrettable confusion here, involving comparison of incomparable processes. Carbon dioxide happens to be a waste product in animal metabolism, but in addition to this in the case of green plants it is also food material. The contrasting of the work of respiration in the two cases upon this basis is wrong, as the author well knows. As a matter of fact, we have no reason to believe that the work of respiration as done by plant protoplasm is more economical than that done by animal protoplasm.

That this book successfully meets the demand intended to be supplied by the author is certain, and this is abundant justification for anyone who has the courage to run the gauntlet with a new book.—RAYMOND H. POND.

Evolution in the potato beetles

Although the work of Professor TOWER[2] on Leptinotarsa deals with a group of animals, his book should not be overlooked by botanists on that account. Probably no work since the appearance of DEVRIES' *Mutationstheorie* is more worthy of careful study. The contribution is essentially along experimental lines, backed by years of observation in the field and laboratory. Many of the problems, if not solved, are seen in clearer light, and at least some of the mooted questions may now be dismissed as answered. Every chapter is of interest to all schools of biologists, but there is space here merely for a few of the more important conclusions. The introductory chapter on geographical distribution and dispersion is followed by chapters on variation, coloration, habits, and instincts. Of intense interest are the final chapters, entitled "Production in experiment of races, new characters, and species in Leptinotarsa," and "The problem of the origin of species." The author believes that only by such careful studies may we ever hope to find out the methods of evolution; we can never solve the problem by inspection. TOWER holds that all organic variations are responses to stimuli; "the most logical interpretation is that this variation is a response of the germ plasm . . . . due to stimuli which produce an inheritable variation differing in no respect in its transmissibility and permanency from the other variations produced." "Variation is . . . . epigenetic and not a predetermined character in organisms." Another important conclusion is that there is no fundamental distinction between fluctuating variations and mutations. TOWER secured as good illustrations of mutation in Leptinotarsa as have been obtained in Oenothera, or better, but no hard and fast lines were to be seen separating these from ordinary variations. The "mutations" differed in that the variations exhibited greater jumps, but they did not differ qualitatively. The experiments fail to support the doctrine of unit characters. In Leptinotarsa also the mutations are orthoge-

[2] TOWER, W. L., An investigation of evolution in chrysomelid beetles of the genus Leptinotarsa. Carnegie Institution of Washington, Publ. no. 48. pp. 320. Washington. 1906.

netic, rather than in all directions, or even in only two directions. "I maintain . . . . that mutation is not a special kind of variability . . . . but it is a part of the normal variability, and the direct response of the germ plasm to stimuli." While these experiments and the conclusions of the author thus seem out of harmony with the views of mutationists, small comfort can be obtained on the other hand by Neo-Lamarckians, for there seems to be no evidence in favor of the notion of the transmission of variations that are found to arise in the soma. Even if such variations are first visible in the soma, they are possible only when the germ plasm has developed a soma capable of variation. The botanists seem to have more generally accepted the theory of mutation than have the zoologists. It scarcely seems possible that one method has been uniformly effective in animal evolution and another as uniformly in plant evolution. Very likely nature has been more multiform in her methods than most of us have yet been willing to believe.—HENRY C. COWLES.

Vegetable physiology

A new edition of GREEN's *Vegetable physiology* has just made its appearance from an American press.[3] Unfortunately the author has not written any preface to the new edition and so what changes he has made can be ascertained only by laborious comparison of the new with the old. The alterations are more numerous than extensive, and it is evident that in large part the old plates are used. Yet the changes suffice for the incorporation of the more important recent advances in the science.

One of the most striking improvements is the transfer of the chapter on respiration from its former connection with the chapter on the aeration of plants to the chapter on the energy of the plant, so that it follows instead of precedes the discussion of food-making and food-getting, digestion, translocation, and storage. The topic might have received more thorough revision in its text to advantage. Other changes are noticeable in the discussion of the absorption of food materials, the chlorophyll apparatus, photosynthesis, and in the nomenclature and classification of proteids.

Not all of the slips have been eliminated in the revision, but the improvement is obvious in bringing the book more nearly up to date. The most striking defects which caught our attention are the retention of the filter theory of dialysis (at least by inference, for the explanation of osmosis is not very clear) and the statement that etiolin is converted into chlorophyll by the action of light. All the recent evidence is against both of these conceptions.

Of all parts of the book the chapters on irritability seem to us most in need of thorough reworking, but this has not been done. Perhaps the author was not free to make changes that would involve extensive resetting of type; as to this he does not take us into his confidence. By and large the book is one of the

[3] GREEN, J. REYNOLDS, An introduction to vegetable physiology. Second edition. 8vo. pp. xx+459. Philadelphia: P. Blakiston's Son & Co. 1907. $3.00.

best brief texts in English that are available for elementary students. Its issue by an American house will make it much more accessible for American students.—C. R. B.

MINOR NOTICES

The vegetation of Texas.—BRAY[4] has made a presentation in a most attractive booklet of the various ecological features of the Texas vegetation. The style of the work is popular, inasmuch as the design of the author was to make the general features of the vegetation of the state a matter of interest to students in the schools and citizens generally. First the factors of plant environment are considered, detailed application being made to the familiar plants of the state. Next follows an account of the plant societies, treated chiefly after the order of SCHIMPER. It is here especially that one may see the astonishing variety that is to be found in Texas. The woodlands range from the fine bottomland and pine forests of the southeast, through post-oak or live-oak forests to the western chaparral. Again in the mountains the characteristic conifer forests of the Rocky Mountains are to be found. There are also extensive areas of prairie and desert. Last of all is considered the vegetation of the water, halophytic areas, and dunes. It is probable that somewhere in Texas any citizen of the entire country (except the far west) could find familiar plant formations, so great is the variety. It is to be hoped that this most excellent work will be made of great use throughout the state. For the purpose it is probably the best work that any of our states possesses. There are some good maps, and a number of photographic representations of characteristic landscapes and vegetation types.—HENRY C. COWLES.

Ecological exploration in northern Michigan.—Few have recently done more to advance the frontier lines of ecology than has C. C. ADAMS,[5] and it may be said that his report on the survey of parts of northern Michigan is the record of essentially pioneer work. This is probably the first paper to extend the principles of physiographic ecology to the biota of a region. It is obvious that the future must see much work of this character, for it is only by such studies as this, carried on by a number of ecological specialists, that the complex interrelations of any biota are to be worked out. There are three special ecological papers in this report. A. G. RUTHVEN, who had charge of the field-work, under the supervision of Mr. ADAMS, presents an account of the regions studied, the Porcupine Mountains and Isle Royale. The chief feature here is the detailed description of the representative stations that were chosen for study. In each case the characteristic plants and animals are noted, and the physiographic and ecological dynamics are elucidated. Papers follow on the ecological distribution of the birds of the

[4] BRAY, W. L., Distribution and adaptation of the vegetation of Texas. Bull. Univ. Tex. 82; Scientific Series 10. pp. 108. Austin. 1906.

[5] ADAMS, CHARLES C., An ecological survey in northern Michigan. From report of Michigan State Board of Geological Survey for 1905. pp. 133. Lansing. 1906.

Porcupine Mountains, by OTTO MCCREARY; and on the ecological relations of the Porcupine Mountain Orthoptera, by A. P. MORSE. The report is concluded by a number of annotated lists.—HENRY C. COWLES.

NOTES FOR STUDENTS

A botanical survey of New Zealand.—We are constantly reminded of the remarkable vegetation of this far away-land through the indomitable energy of COCKAYNE,[6] whose ecological studies are always of the highest value. The island whose flora is here considered is one of the three that been has long set apart as a preserve through the commendable foresight of the New Zealand government. Perhaps the most interesting formation of the island is the forest, made up of a number of the characteristic New Zealand trees, whose distribution is related to wind in a most striking way. The heaths, the scrub, the strand, etc., are more briefly described, and then follows an interesting chapter on the affinities of the flora. The paper is accompanied with representative formation photographs, and a list of the species with Latin, English, and Maori names. The New Zealand government, which has made possible COCKAYNE'S study of the island, and which has published this valuable report, is to be most heartily congratulated for its good sense. It is to hoped that the government will find a way to employ COCKAYNE'S services for similar work all over the country, and especially because he is the man best fitted for this work. This is an admirable undertaking for any government, and particularly for New Zealand, since its flora is without counterpart elsewhere, and seems to be more than commonly subject to destruction by the ravages of man.—HENRY C. COWLES.

Alpine flora of Argentina.—R. E. FRIES[7] has given an account of some interesting Argentine plant formations, chiefly in the northwest Cordjilleran region. The region as a whole is very xerophytic, and the most striking plant formation oi another type is the Hypsela formation, which is found along the stream courses, reminding one in a small way of the forest belts along streams in our prairie districts. The chief non-halophytic desert formations are the Hoffmanseggia, cactus, and Azorella formations. All are characterized by a dominance of xerophytic shrubs, but the Hoffmanseggia formation is the characteristic formation of the sandy plateaux, while the cacti dominate more on the stony hills. The Azorella formation is on the higher hills and is closely related to the cactus formation. Above the Azorella are lichen deserts. There are also regions of dunes some of which are dominated by Patagonium, others by Lampaya. Halophytic areas are extensive, some being dominated by *Salicornia pulvinata*, others by *Sporobolus arundinaceus*, and still others are shrubby areas with a dominance of

[6] COCKAYNE, L., Report on a botanical survey of Kapiti Island. pp. 23. Wellington. 1907.

[7] FRIES, R. E., Zur Kenntniss des alpinen Flora im nördlichen Argentinien. Nov. Act. Reg. Soc. Sci. Upsal. IV. 1:1–205. 1905.

Lepidophyllum. These chapters are followed by a discussion of the floristic and ecological relationships of the plants, a table of the species with ample taxonomic notes, and some good plates of representative plants and plant formations.—HENRY C. COWLES.

Galvanotropism again.—Miss BAYLISS,[8] working at Birmingham under the direction of EWART, has studied the effect of electric currents applied directly to roots by electrodes, polarizable and non-polarizable, and indirectly by imbedding seedlings in a 3 per cent. gelatin solution between platinum electrodes 10–12^{cm} apart. The currents used were 4.2 volts with the resistance that of the gelatin for 48 hours, or of the roots alone (3–8 minutes), or 150,000 ohms, applied for 5 to 48 hours, or 220 volts with 2220 ohms applied for 50 seconds. She finds that it makes a difference where the electrodes are placed; when on opposite sides of the sensitive (growing) region the curvature is always toward the cathode, but if one is nearer the apex than the other the curvature is toward the apical electrode. Unlike PLOWMAN, whose papers she has overlooked, she found that curvatures could be produced without injury, even by strong currents of short duration. Contrary to GASSNER, whose mode of experimentation she deprecates; she concludes that the curvatures are due to the ions produced by electrolysis and that galvanotropism therefore is a form of chemotropism, and not necessarily of traumatropism.—C. R. B.

Embryogeny in Ephedra.—*Ephedra distachya* has been studied recently by Miss BERRIDGE and Miss SANDAY,[9] who find two markedly unequal male nuclei lying in a common cytoplasmic mass. The functioning male nucleus slips out of the cytoplasmic mass and passes to the egg nucleus. Although no case of fusion was observed, fertilization is thought to occur because proembryos are found which the authors can account for in no other way than by supposing fertilization has occurred. The jacket cells arise at the same time as the central cells. Later the nuclei of the jacket cells divide by direct division, the binucleate cells enlarge and become gorged with food, and the wall of the egg breaks down, permitting the jacket nuclei to escape. The jacket nuclei fuse in pairs within the egg and give rise to proembryos. In some cases the proembryos are merely enlarged jacket cells, proembryonal cells occur within jacket cells not adjacent to archegonia, and migration and fusion of the nuclei of neighboring jacket cells precede the formation of these proembryos. These are startling claims to make in connection with the embryogeny of a gymnosperm.—W. J. G. LAND.

Items of taxonomic interest.—N. C. KINDBERG (Rev. Bry. **34**:87–92. 1907), in notes on North American mosses, has described new species under Pseudoleskeella, Hypnum (2), Dichodontium, Grimmia (2), Bryum (4), and Pohlia.—

[8] BAYLISS, JESSIE S., On the galvanotropism of roots. Annals of Botany **21**: 387–405. *figs. 6.* 1907.

[9] BERRIDGE, ETHEL M., and SANDAY, ELIZABETH, Oogenesis and embryogeny in *Ephedra distachya*. New Phytologist **6**:128–134, 167–174. *pls. 3, 4.* 1907.

M. L. FERNALD (Rhodora **9**:140–146. 1907), in a presentation of the genus Suaeda in northeastern America, recognizes 4 species and describes one as new (*S. Richii*).—G. F. ATKINSON and C. W. EDGERTON (Jour. Mycol. **13**:185, 186. 1907; also Science N. S. **26**:385, 386. 1907) have published a new genus (*Protocoronospora*) of fungi discovered infecting the cultivated vetch, and have published it in two journals without any evidence as to which publication is to be regarded as the original one.—C. H. PECK (Bull. Torr. Bot. Club **34**:345–349. 1907) has described 12 new species of fleshy fungi, distributed among 8 genera.—E. HASSLER (Bull. Herb. Boiss. II. **7**:718–740. 1907), in continuation of his *Plantae Paraguariensis*, publishes a new genus (*Paradolichandra*) of Bignoniaceae.—L. RADLKOFER (Leaflets Philippine Bot. **1**:208–211. 1907) has published 4 new species of Sapindaceae from the Philippines.—J. M. C.

Movement of water.—DIXON adduces experimental evidence[10] that EWART'S estimates[11] of the velocity of the transpiration stream and the resistances it encounters are vastly too great. EWART calculated from his data that it would require a head of water 6–33 times the height of the tree to drive a sufficient amount of water against the resistance encountered. According to DIXON'S data, with liberal allowances for transpiration, it would suffice to have a head equal to the height of the tree. As to the soundness of the cohesion theory of the ascent of water, against which EWART had brought his conclusions as objections, DIXON says: "Apart from the weighty evidence which has elsewhere been adduced in its favor, the fact that other theories, both old and new, have to assume properties for the waterways of plants which are either in the highest degree improbable . . . . or are even directly negatived by experiment, seems to support the theory by a process of exclusion."—C. R. B.

Light perception.—Another adverse report on HABERLANDT'S theory of the lens-function of the epidermal cells in the perception of light is rendered by NORDHAUSEN.[12] Unlike HABERLANDT, who obliterated the lens action by a film of water, and KNIEP who reversed it by paraffin oil, NORDHAUSEN used a film of 5–10 per cent. gelatin, whose refractive index is almost that of cell contents. (By making the gelatin opaque with lamp black he used it also to exclude light from the petiole, for which it is much superior to leather or paper.) He found that the clear gelatin did actually eliminate the lens action of the convex cells, and testing the ability of the leaf to respond to light in the very plants used

[10] DIXON, H. H., On the transpiration current in plants. Proc. Roy. Soc. London B. **79**:41–57. 1907.

[11] EWART, A. E., Ascent of water in trees. Phil. Trans. Roy. Soc. London B. **198**:41–85. 1905. Also, The resistance to flow in wood vessels. Annals of Botany **19**:111. 1905.

[12] NORDHAUSEN, M., Ueber die Bedeutung der papillösen Epidermis als Organ für die Lichtperception des Laubblattes. Ber. Deutsch. Bot. Gesells. **25**:398–410. 1907.

by HABERLANDT, he reports uniformly positive results, both with and without the darkening of the petiole; whence he concludes that "the lens-function does not stand in direct causal connection with the perception of the direction of light by the leaf-blade."—C. R. B.

Branching in palms.—In 1892 MORRIS[13] brought together what had been recorded concerning the branching of palms, which was regarded as an abnormal phenomenon. RIDLEY,[14] who has had eighteen years of experience in the oriental tropics, has now much extended our knowledge of this phenomenon. He believes that the greater number of palms are branched at least at base, and that the production of a single axis from a seed may be regarded as the "abnormal" condition. Lateral buds are produced at or near the base, and these become erect stems, in some cases the whole plant eventually becoming a bush; or these lateral buds may develop as subterranean branches that send up a succession of erect stems (branches). Heretofore the branching of palms has been thought of only in connection with the crown, but RIDLEY's observations indicate that the group is perhaps characterized by a tendency to basal branching.—J. M. C.

Spirogyra.—Dr. FRITSCH and Miss RICH[15] have begun a series of studies of the British freshwater algae, the first one dealing with Spirogyra. The principal topics are: "The occurrence of Spirogyra in nature," "The reproduction of Spirogyra in nature," and "Points of systematic interest." The species examined were either purely vernal or exhibited both a vernal and an autumnal phase. The autumnal appearance of certain species is thought to be due to certain external conditions that cause a small number of zygospores to germinate. "Reproduction takes place ordinarily in the vernal phase, and is most probably the result of certain periodically recurring combinations of factors, which vary for different species;" in support of which view the authors present a considerable number of data.—J. M. C.

Limiting factors and growth.—A. M. SMITH, late a pupil of BLACKMAN at Cambridge, has carried out a thorough study of the rate of growth in a number of plants at different stations in Ceylon, applying to the discussion of his results[16] BLACKMAN's fruitful theory of limiting factors. In Agave and Furcraea tem-

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[13] MORRIS, DANIEL, On the phenomena concerned in the production of forked and branched palms. Jour. Linn. Soc. London Bot. **29**:281. 1892.

[14] RIDLEY, H. N., Branching in palms. Annals of Botany **21**:415–422. *pls. 34–39*. 1907.

[15] FRITSCH, F. E., and RICH, FLORENCE, Studies on the occurrence and reproduction of British freshwater algae in nature. I. Preliminary observations on Spirogyra. Annals of Botany **21**:423–436. 1907.

[16] SMITH, A. M., On the application of the theory of limiting factors to measurements and observation of growth in Ceylon. Annals Roy. Bot. Gardens Peradeniya **3**:303–375. *pls. 22–25*. 1907.

perature (probably the internal temperature of the growing parts) always was the limiting factor, while in Dendrocalamus sometimes the water supply, sometimes the temperature was limiting. In Capparis and Stifftia it seems to be the water supply by day and temperature by night; in Vitis the temperature in January, and the water supply in July. The paper is a most suggestive one. It seems quite likely the conflicting data on growth can be harmonized by further study along this line.—C. R. B.

Infectious chlorosis.—BAUR[17] reports that the variegated forms of *Ligustrum vulgare*, *Liburnum vulgare*, *Fraxinus pubescens*, *Sorbus aucuparia*, and *Ptelea trifoliata*, which are propagated by cuttings, owe their yellow or variegated leaves to an infectious chlorosis like that recently described in detail for *Abutilon Thompsoni*. A yellow variety of *Ptelea trifoliata*, however, which can be grown from seed, is a true *aurea*-form, and its condition is not transmissible by infection. BAUR expects to find this disease widespread, when time avails for examining the many wild and commercial variegate-leaved plants. He intends to make his next task the isolation of the problematic infecting material.—C. R. B.

The primary uredospore.—CHRISTMAN[18] has investigated the development of the so-called primary uredospore of *Phragmidium potentillae canadensis*. He brings out the resemblance between the true aecidium and the primary uredo, the spores in the two cases being morphological equivalents. The relation of these results to the life-history as a whole is presented in a later paper published in this journal.[19]—J. M. C.

Anaerobic respiration.—STOKLASA and his collaborators[20] report further successful isolation of the enzymes which in the absence of oxygen break up carbohydrates in plant cells into lactic acid, and then into alcohol and CO_2. Zymase is responsible for the lactic acid; lactacidase for the alcoholic fermentation, with hydrogen as a by-product. This seems indirectly to support POLLACCI's hypothesis that in photosynthesis we have reduction of CO_2 by H.—C. R. B.

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[17] BAUR, ERWIN, Ueber infektiöse Chlorosen bei Ligustrum, Laburnum, Fraxinus, Sorbus, und Ptelea. Ber. Deutsch. Bot. Gesells. **25**:410–413. 1907.

[18] CHRISTMAN, A. H., The nature and development of the primary uredospore. Trans. Wis. Acad. Sci. **15**:517–526. *pl. 29.* 1907.

[19] CHRISTMAN, A. H., Alternation of generations and the morphology of the spore forms in rusts. BOT. GAZETTE **44**:81–101. *pl. 7.* 1907.

[20] STOKLASA, ERNST, and CHOCENSKÝ, Ueber die anaerobe Atmung der Samenpflanzen und über die Isolierung der Atmungsenzyme. Ber. Deutsch. Bot. Gesells. **25**:122–131. 1907.

NEWS

DR. RAYMOND H. POND, recently of the New York Botanical Garden, has sailed for Germany, to study under PFEFFER at Leipzig.

DR. RICHARD WETTSTEIN, Vienna, has been elected president of the "Association of German Men of Science and Physicians," to meet next year at Cologne.

DR. EZRA BRAINERD, well known among botanists for his work on the flora of Vermont, has resigned the presidency of Middlebury College, an institution which he has served for 43 years.

THE *Bryologist* for November offers the usual interesting fascicle of notes on mosses, liverworts, and lichens. The brief contributions of many observers and students of these plants are of real service.

PROFESSOR J. BEHRENS has been called to the directorship of the biological Experiment Station at Berlin-Dahlem (the seat also of the Imperial Botanic Garden), as successor to the late Professor R. ADERHOLD.

J. ARTHUR HARRIS, Missouri Botanical Garden, has been appointed on the staff of the Carnegie Station for Experimental Evolution at Cold Spring Harbor, to succeed E. N. TRANSEAU, now at the State Normal School, Charleston, Illinois.

PROFESSOR LUDWIG JOST, of the University of Strassburg, has been called to the State Agricultural College at Bonn-Poppelsdorf and to an assistant professorship in the University of Bonn, as successor to Dr. FRITZ NOLL, who went to Halle.

IN THE September number of the *Chautauquan*, a series of articles, entitled "Some great American scientists," begins with a biographical sketch of ASA GRAY, by Professor C. R. BARNES. The frontispiece of the number is a portrait of Dr. GRAY.

MR. A. H. CURTISS, the well-known collector of plants from the southeastern United States and West Indies, whose sets are widely distributed and highly prized in the herbaria of the world, died at his home in Jacksonville, Florida, September 1, at the age of 62 years.

J. E. KIRKWOOD, formerly of Syracuse University, has been appointed assistant botanist to the Mexican-Continental Rubber Company, whose laboratory is at Hacienda de Cedros, Mazapil, Zacatecas. It is in this company that FRANCIS E. LLOYD is director of investigation, with the same laboratory address.

CLARK HALL, of the Massachusetts Agricultural College, the new building named after Colonel WILLIAM S. CLARK, an enthusiastic botanist and one of the first presidents of the institution, was dedicated on October 2. Addresses were given by Professor D. P. PENHALLOW, McGill University, on "William Smith Clark: his place as a scientist and his relation to the development of scientific agriculture;" and by Professor JOHN M. TYLER, Amherst College, on "Reminiscences of Colonel W. S. Clark."

GENERAL INDEX

The most important classified entries will be found under Contributors, Personals, and Reviews. New names and names of new genera, species, and varieties are printed in **bold-face** type; synonyms in *italic*.

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